The ACE Grain Flow Model: Background, Model and Data

February 14 2007,

To the Navigation Economic Technologies (NETS) Grain Forecast Modeling and Scenarios Workshop,

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Paper/reports are as follow

- Available at WWW/nets
  - *Longer-Term Forecasting of Commodity Flows on the Mississippi River: Application to Grains and World Trade*
  - Appendix titled *Longer-Term Forecasting of Commodity Flows on the Mississippi River: Application to Grains and World Trade: Appendix*
  - *IWR Report 006-NETS-R-12*
- http://www.nets.iwr.usace.army.mil/docs/LongTermForecastCommodity/06-NETS-R-12.pdf
- NDSU Research Reports forthcoming

Outline of Topics: ACE I

- Background
- Model description
- Summary of critical data
- ACE II: Additional restrictions, calibration, results and summary

Analytical Challenge and Background

- Panama Canal Expansion Project and Analysis
  - Simply expand/update/revise
- Data: Needed to be replicatable/ observable and scientifically defendable
- Focus two extreme scopes of analysis in one
    - Extreme detail on US intermodal competition including inter-reach competition!
    - Macro trade and policies
  - 50 year projections

Overall Approach

- Data
- Assumptions
- Model
- Results

NAS Review: Key Points and Major Changes

- Drop wheat from model
- *Supply/Demand data.* Data updated to most recent available
- *Domestic demand by crop and state:* Use *ProExporter* data. Comment on USDA
- *Ethanol.* Data and related issues updated and more detail
- Barge rates: replaced means with barge rate functions
- *Brazil shipping costs*. revised using shipping costs concurrent with base period and which are now reported in USDA Grain Transportation.
- *Interior shipping restrictions* Restrictions on port/river handling were removed (notably STl and NOrleans)
- *Rail car capacity* was added as a restriction,
- *Truck rates*. Shipping rates to the river were revised and taken from Dager (forthcoming).
- *Calibration:*
  - extensive comparisons of model results to actual rail and barge shipments during the base period.
  - When/if there was a difference, we compared the elements of costs to identify the reasons for this difference.
  - Selectively imposed restrictions to reduce the number of flows that did not conform to actual. These are summarized on p. 11 of the Appendix (and below)

Model Dimensions and Scope

Major components of the model

- Consumption and import demand:
  - Estimates of consumption were generated based on incomes, population and the change in income elasticity as countries mature. For the United States, ethanol demand for corn was treated separately from other sources of demand.
- Export supply: For each exporting country and region, export supply is defined as the residual of production and consumption.
- Costs Included:
  - Production (Variable) costs
  - Shipping by truck, rail, barge and ocean
  - Barge delay costs (nonlinear)
  - Handling costs
  - Import tariffs, export subsidies and trade restrictions
- Model dimensions: The model was defined in GAMS and has
  - 21,301 variables
  - 761 restrictions.

Model Details

- Production calculations
  - Max area potential:
    - HA=*f*(trend)
  - Total area subject to max % increase from base period
  - Max switching between crops:
    - 12% (base) -20%
  - Yields=*f*(trend)
- Model chooses least cost solution and derives
  - Area planted to each crop by region
  - Production
  - Consumption
  - Trade
  - Route, inter-reach allocation and intermodal allocation

Objective Function

$$W = \sum_c \sum_i (PC_{ci} - S_i) A_{ci} + \sum_c \sum_i \sum_j t_{cij} Q^t_{cij}$$
$$+ \sum_c \sum_i \sum_w t^R_{cij} Q^R_{cij} + \sum_c \sum_i \sum_w t^t_{ciw} Q^t_{ciw}$$
$$\sum_c \sum_i \sum_p t_{cip} Q^R_{cip} + \sum_c \sum_i \sum_w (t_{cwp} + B_p) Q^B_{cwp}$$
$$+ \sum_c \sum_p \sum_q (t_{cpq} + r_q) Q_{cpq}$$

where
i=index for producing regions,
j=index for consuming regions,
p=index for ports in exporting countries,
q=index for ports in importing countries,
w=index for river access point on the Mississippi River system,
B=barge,
R=rail,
T=truck,
PC_{ci}=production cost of crop c in producing region i,
A_{ci}=area used to produce crop c in producing region i,
t=transportation cost per ton,
Q=quantity of grains and oilseed shipped,
S=production subsidies in the exporting country;
r=import tariffs in the importing country;
B=delay costs associated with barge shipments on each of four reaches on the Mississippi river.

Restrictions

1) $$Y_{ci} A_{ci} \geq \sum_{j} Q_{cij} + \sum_{p} Q_{cip}$$

2) $$\sum_{c} A_{ci} \leq TA_{i}$$

3) $$A_{ci} \geq MA_{ci}$$

4) $$\sum_{i} Q_{cij} + \sum_{q} Q_{cqj} \geq MD_{cj}$$

5) $$\sum_{c} \sum_{i} Q_{cip} \leq PC_{p}$$

6) $$\sum_{c} \sum_{i} Q_{ciw} \leq LD_{w}$$

7) $$\sum_{i} Q^{R}_{cip} + \sum_{w} Q^{R}_{cwp} \geq MQ_{cp}$$

8) $$\sum_{i} Q_{cip} = \sum_{q} Q_{cpq}$$

9) $$\sum_{p} Q_{cpq} = \sum_{j} Q_{cqj}$$

where

y=yield per hectare in producing regions in exporting countries,
TA=total arable land in each producing regions in exporting countries,
MA=minimum land used for each crop in producing regions in exporting countries,
MD=forecasted domestic demand in consuming regions in exporting countries and import demand in consuming regions in importing countries,
PC=handling capacity in each port in both exporting and importing countries,
LD_w throughput capacity for grains and oilseeds at river access point W,
MQ_p in the minimum quantity of each crop shipped through each port in the U.S.

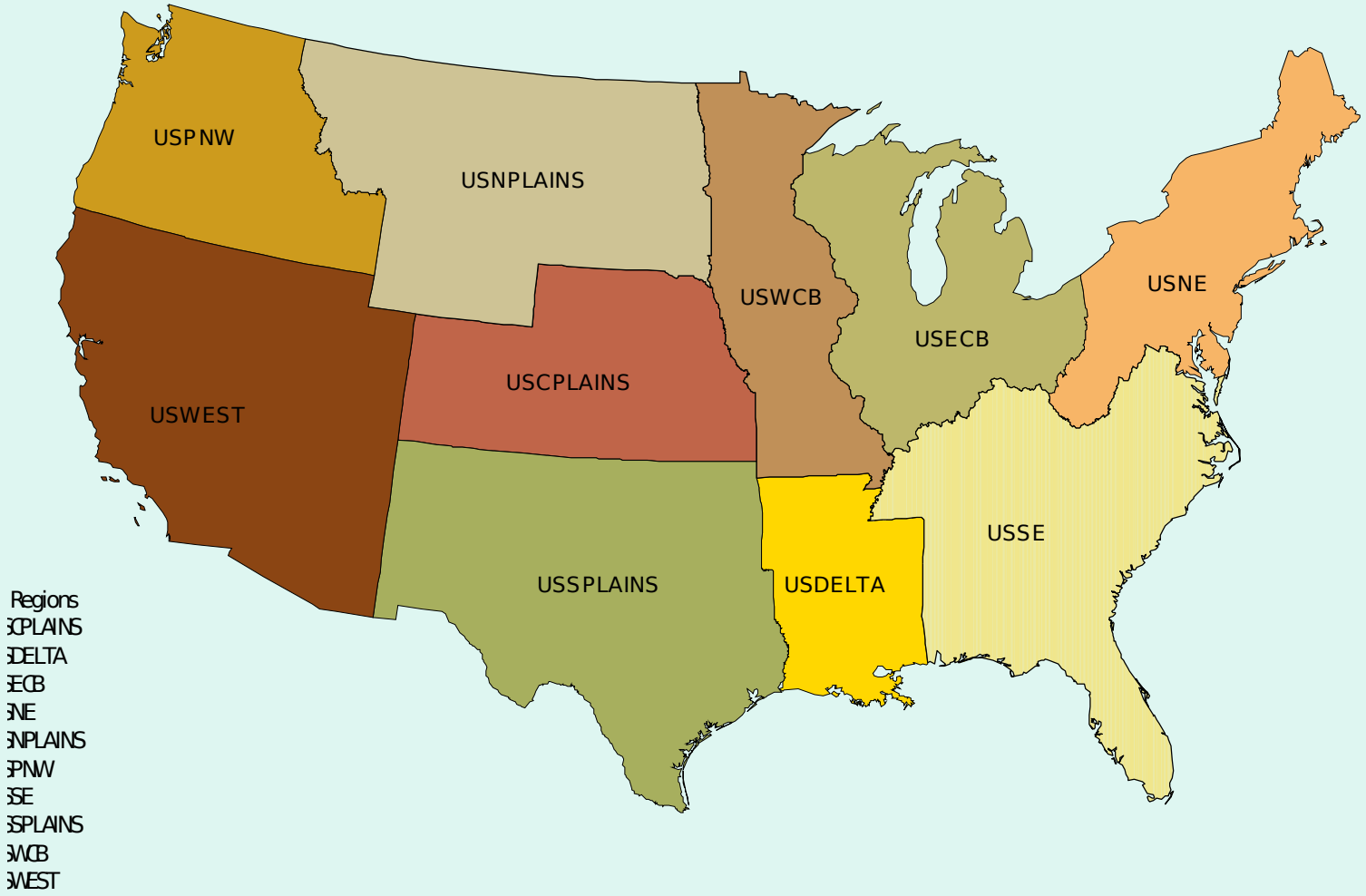
Other restrictions: Wheat

- Due to a cumulation of peculiarities on wheat trade and marketing, mostly due to cost differentials and quality demands
  - imposed a set of restrictions to
  - ensure countries' trade patterns were represented
  - allow some inter-port area shifts in flows within North America
  - Allow growth to occur with similar shares

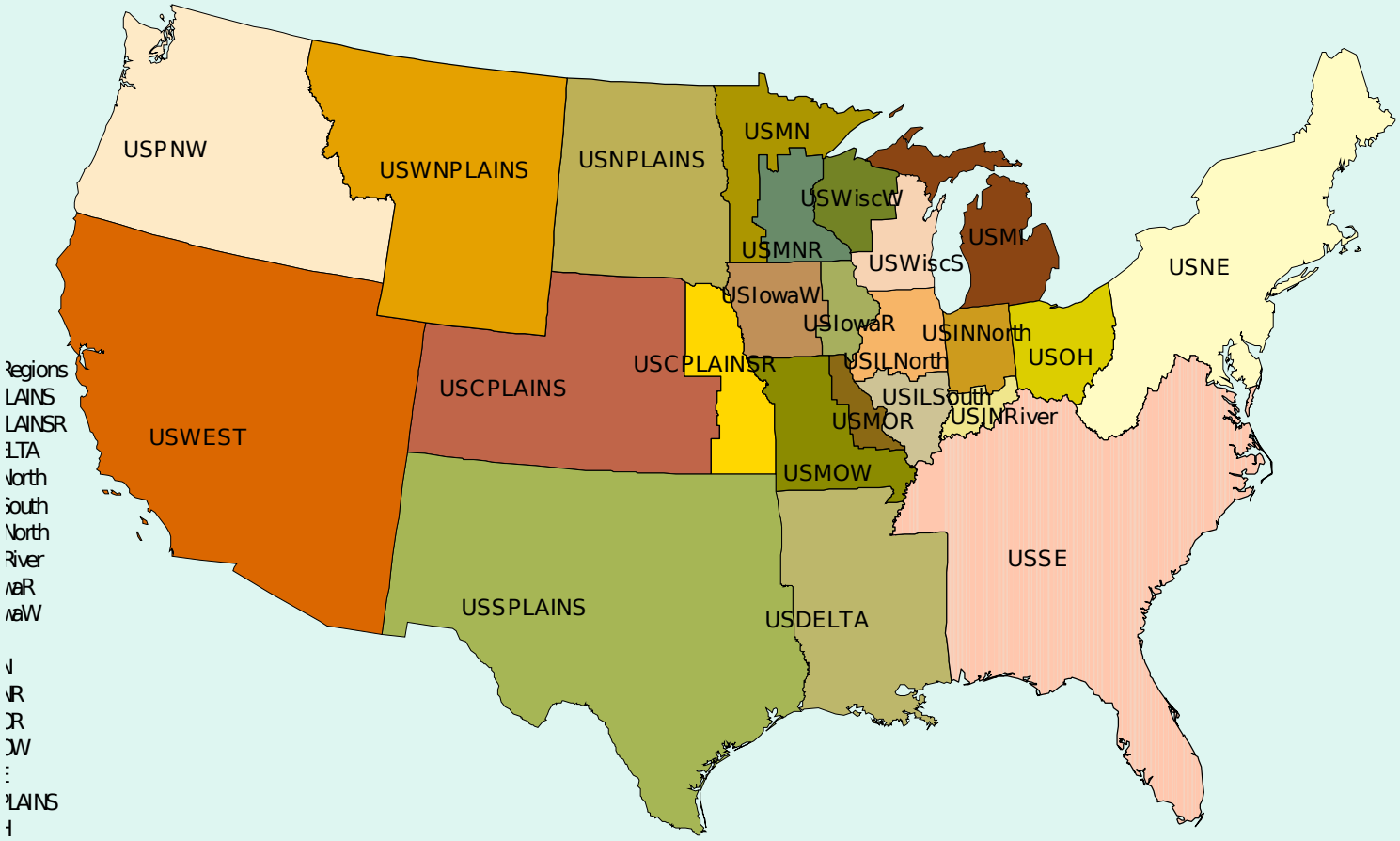
Other

- Base case and other restrictions discussed in ACE 2 (concurrent with results)

US Consumption Regions



US Production Regions

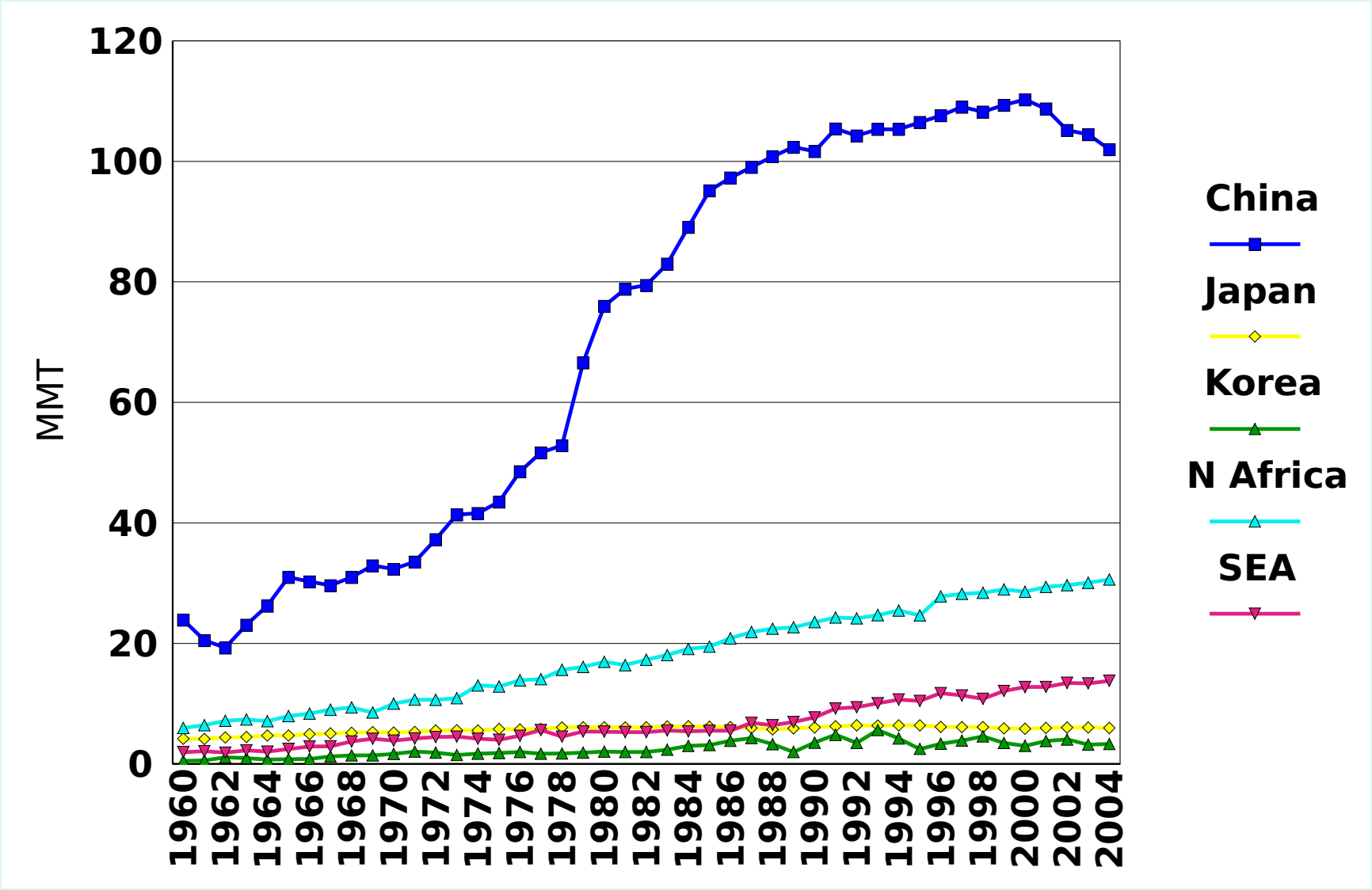


Background: Data and Observations Impacting results

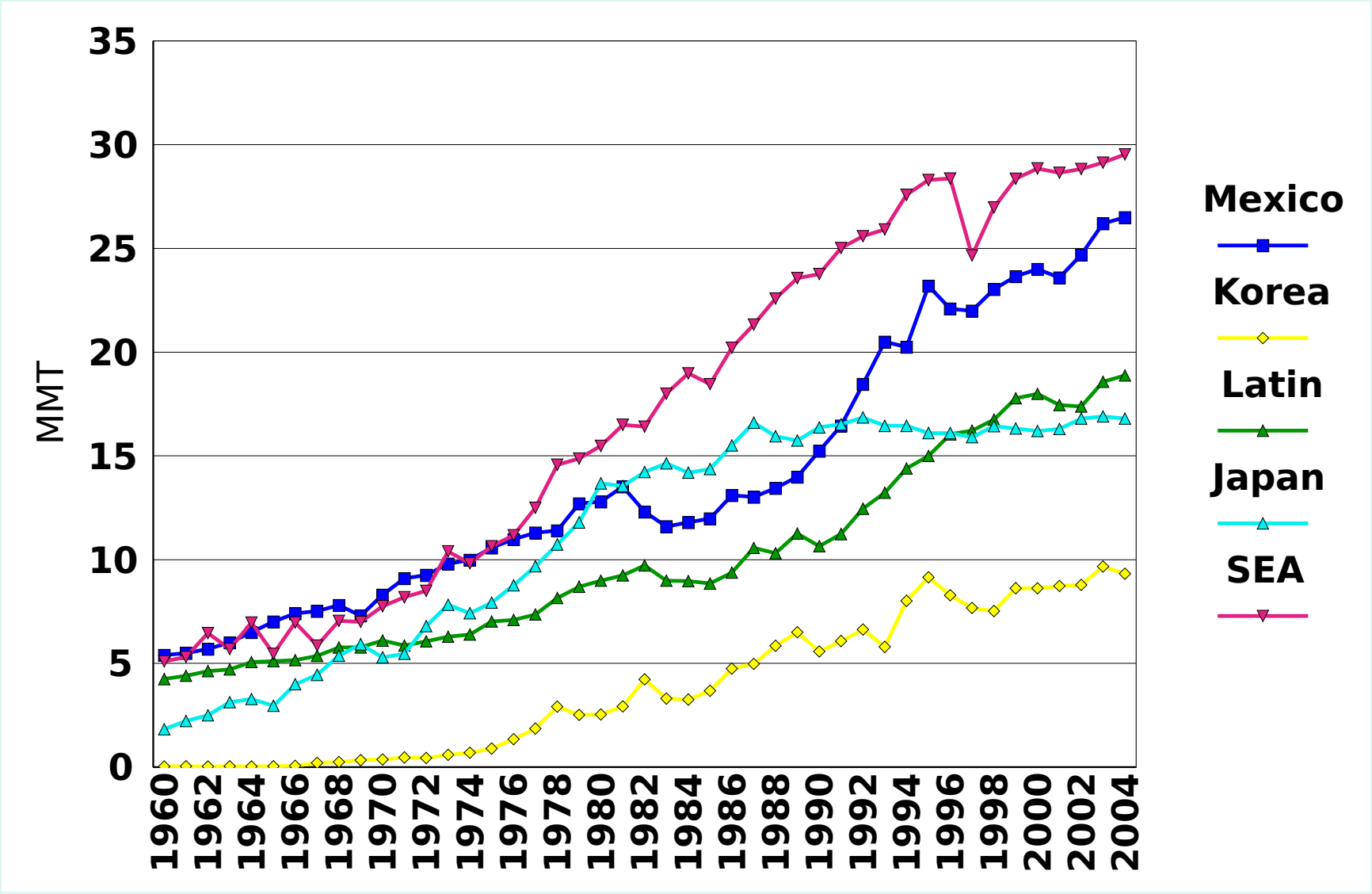
- Consumption
- Production costs
- Yields, CRP etc.
- Ethanol

Consumption

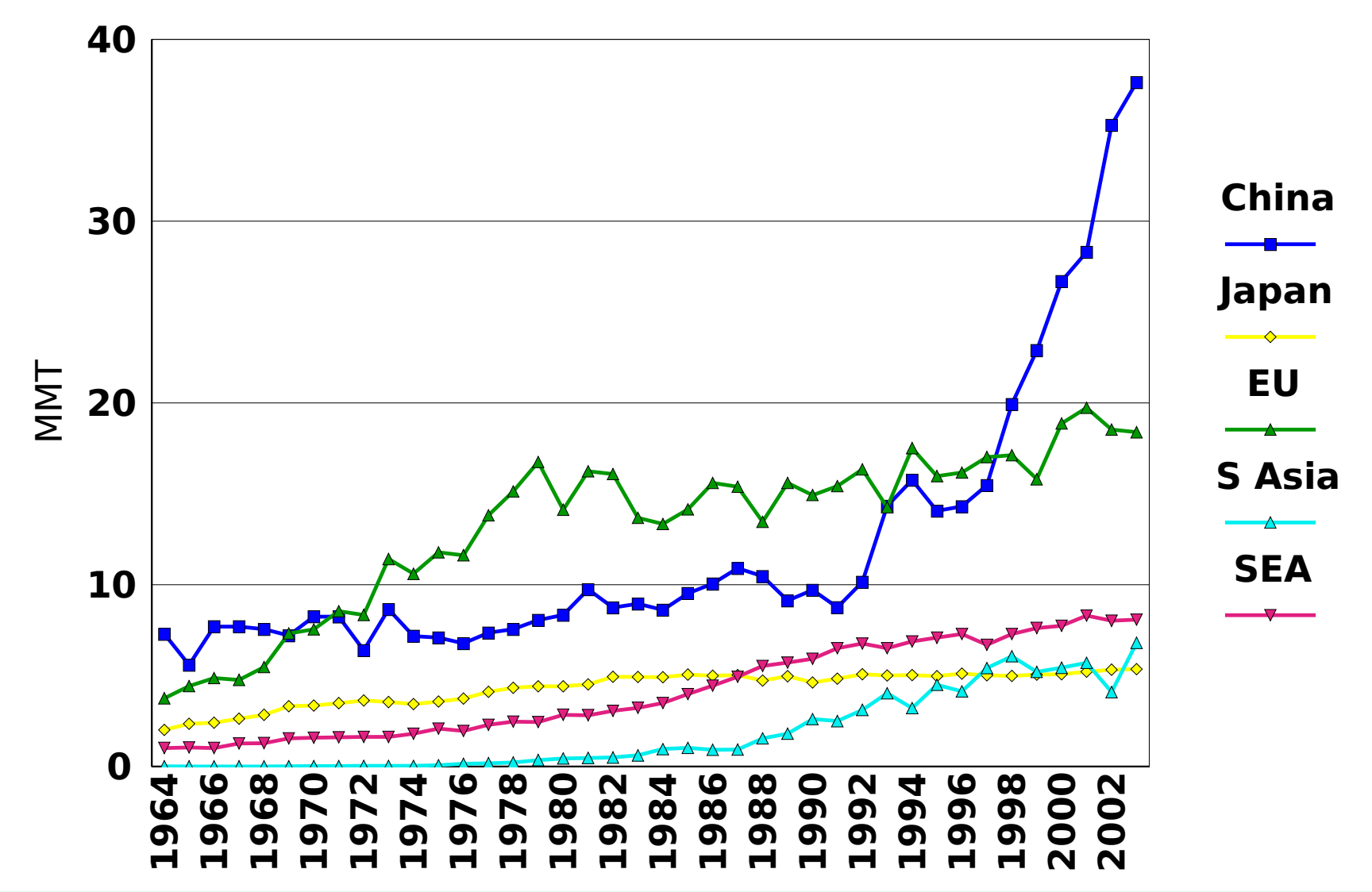
Wheat: Consumption by Selected Importers



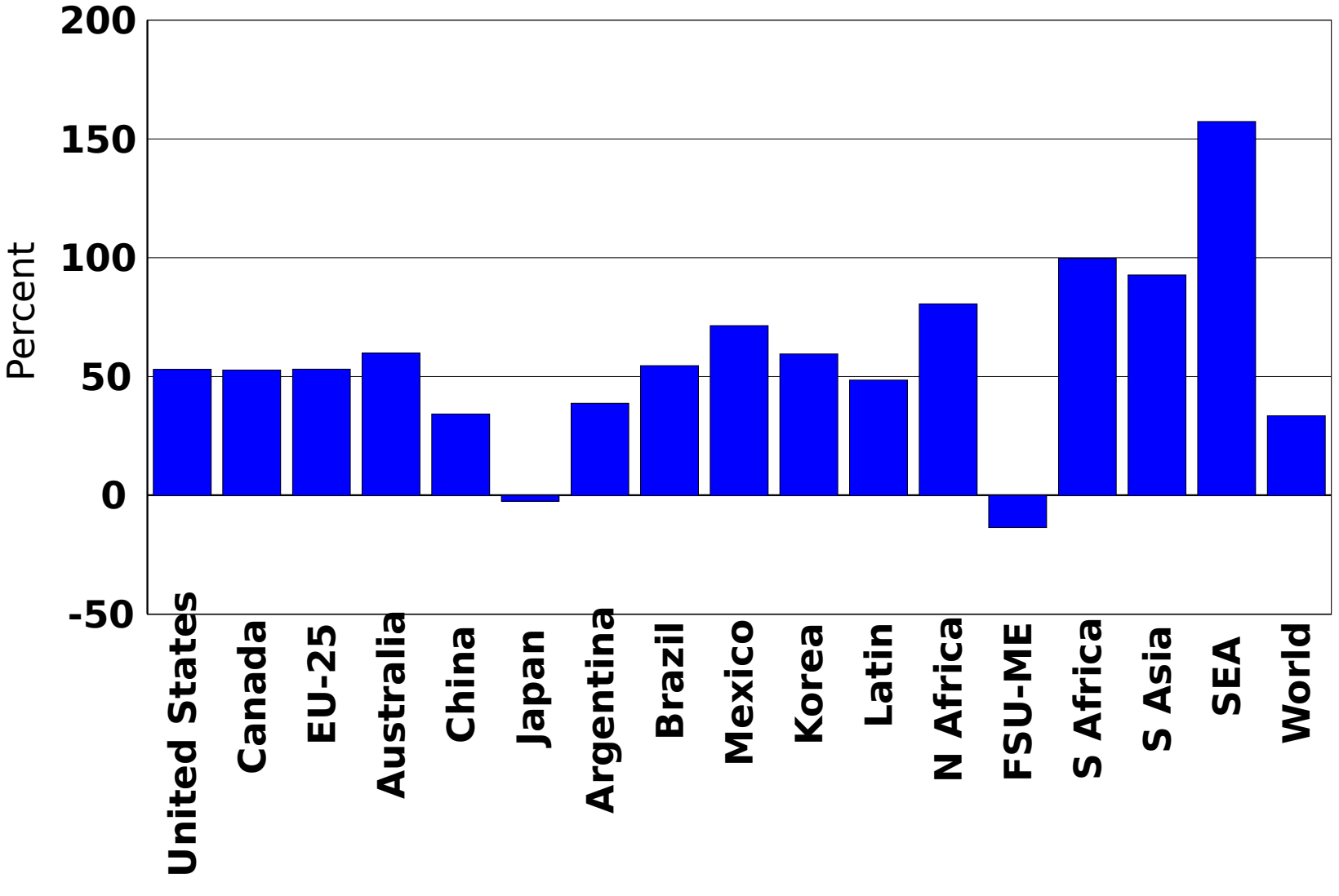
Corn: Consumption by Selected Importers



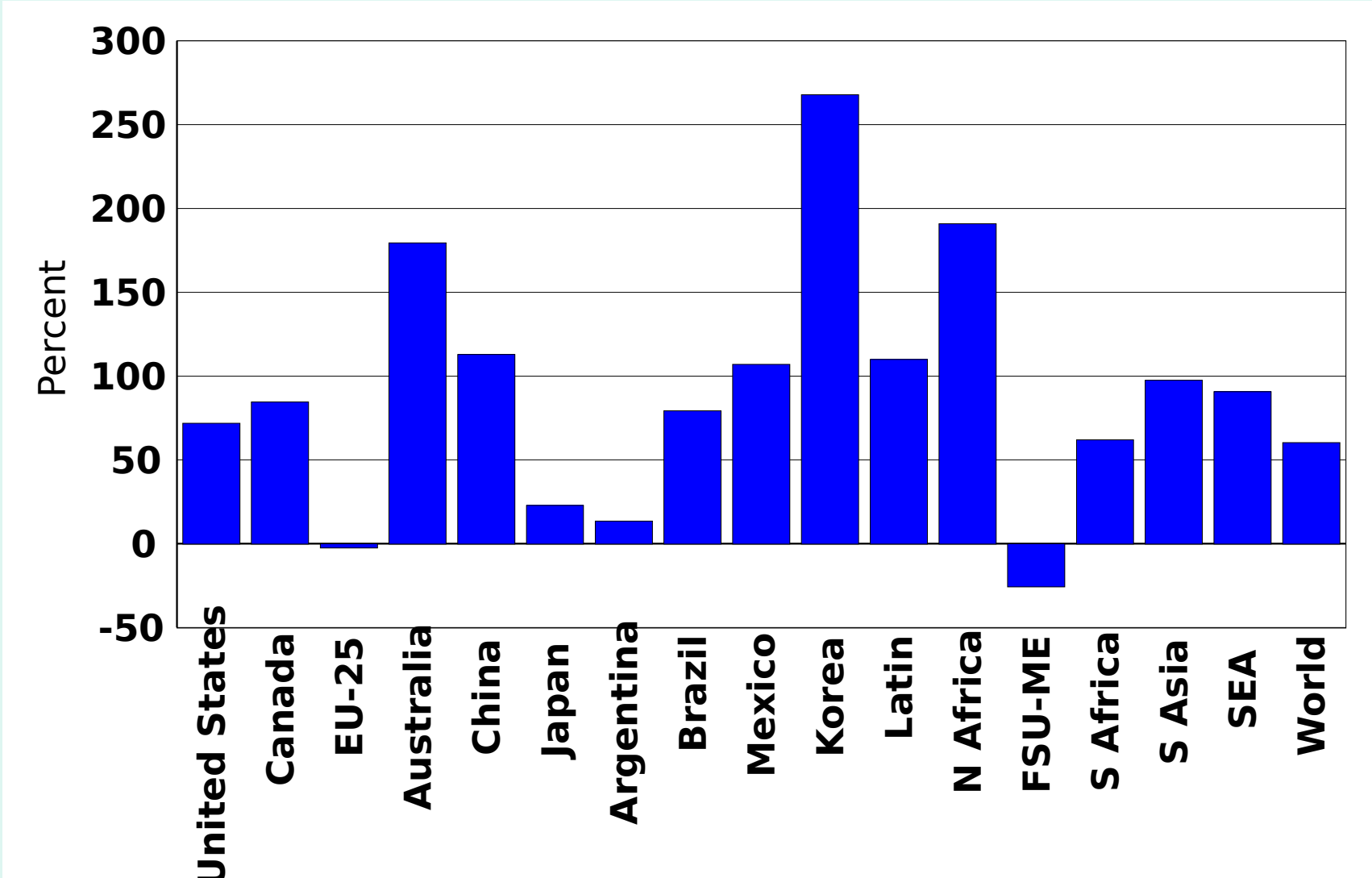
Soybean: Consumption by Selected Importers



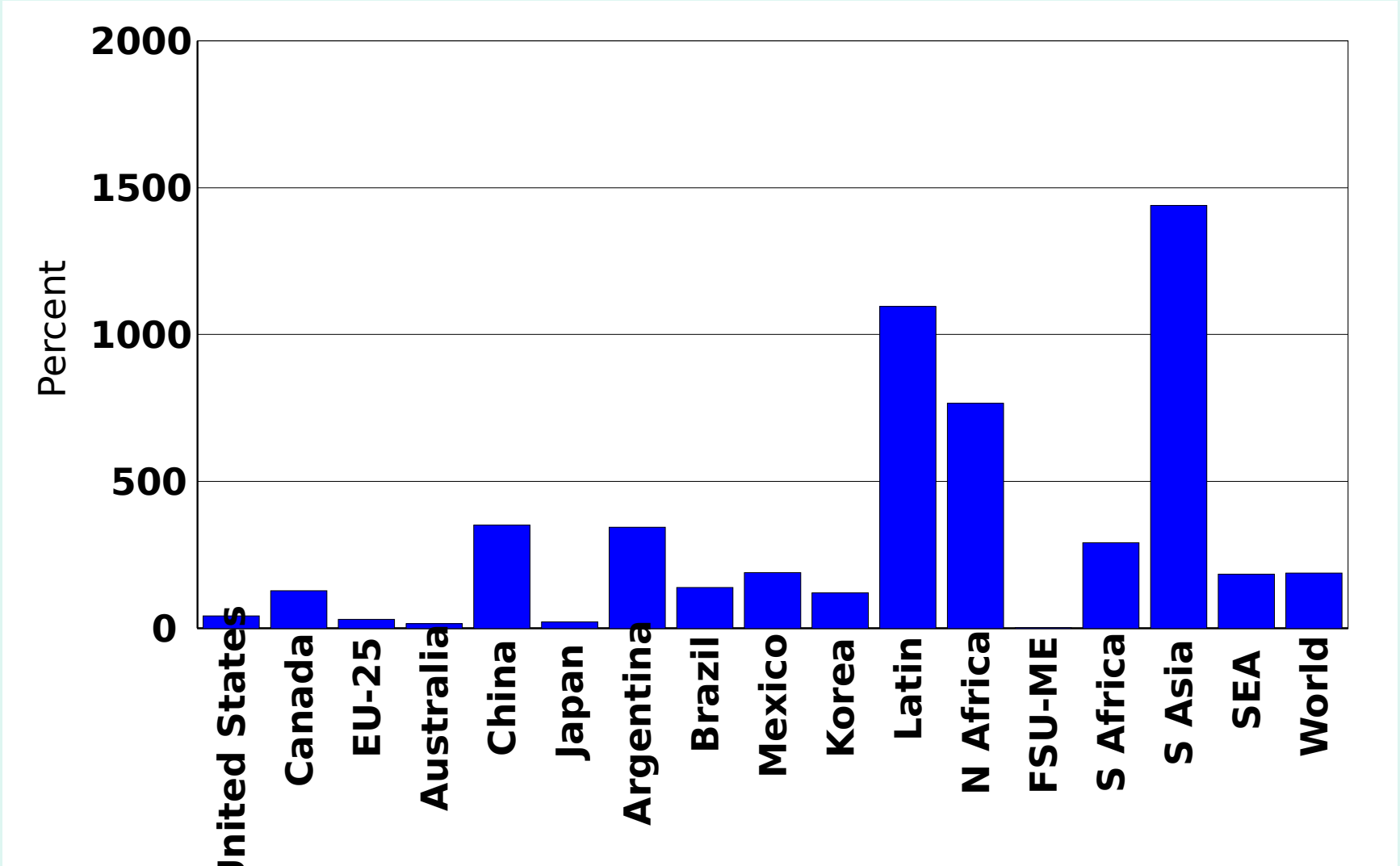
Change in World Wheat Consumption, 1980-2004



Change in World Corn Consumption, 1980-2004



Change in World Soybean Consumption, 1980-2004



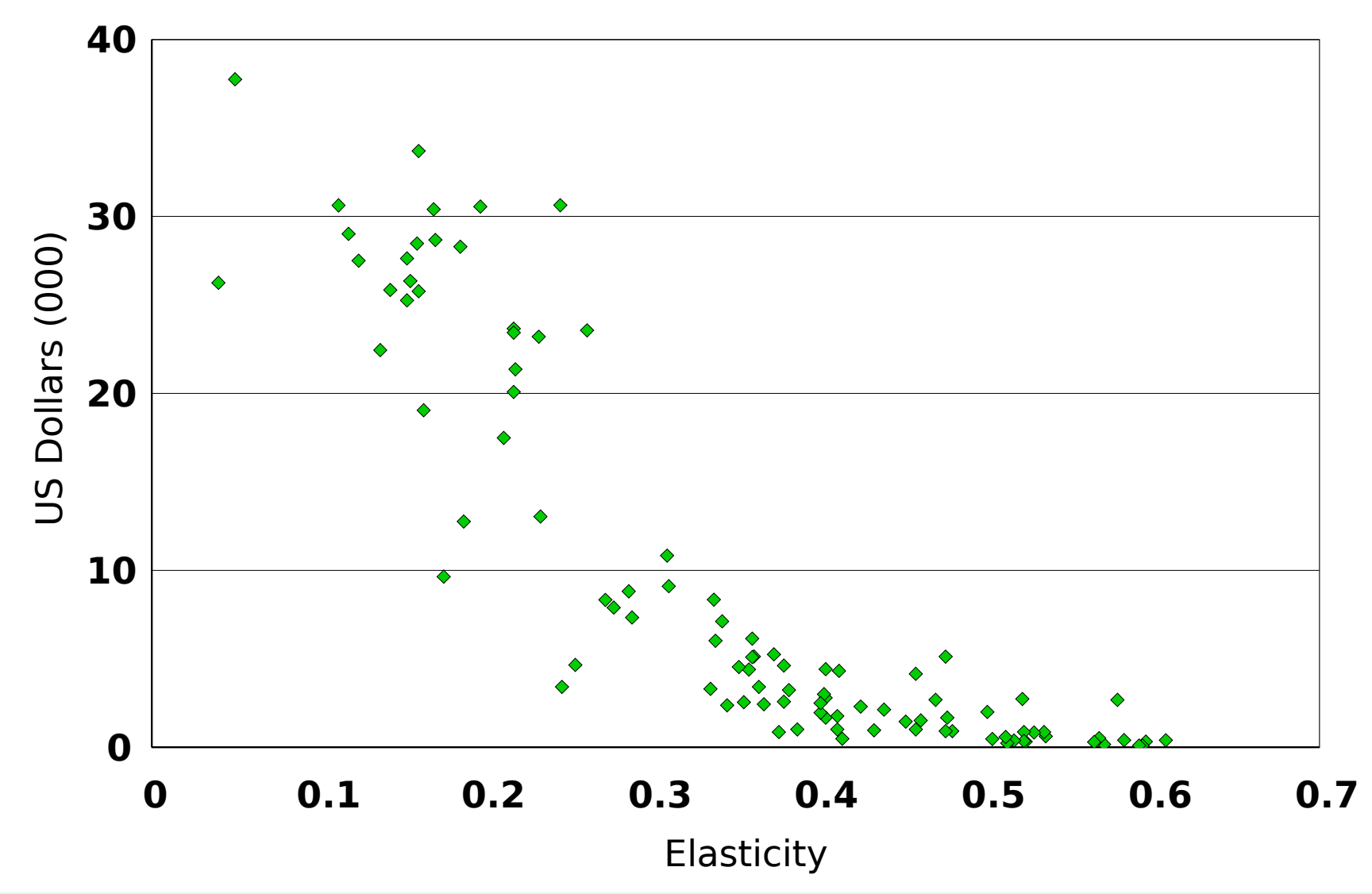
Consumption Functions

- Changes in consumption as countries' incomes increase
- Econometrics:
  - *C=f(Y)*
    - C=consumption and Y=income
    - For each country and commodity using time series data
    - Use to generate elasticity for each country/commodity
  - *E=f(Y)*
    - E= Elasticity
    - Non-linear
    - Across cross section of time series elasticity estimates
    - Allow elasticities for each country to change as incomes increase
- Derive projections
  - Use WEFA income and population estimates
  - Derive consumption as
    - *C=C+%Change in Y X Elasticity*

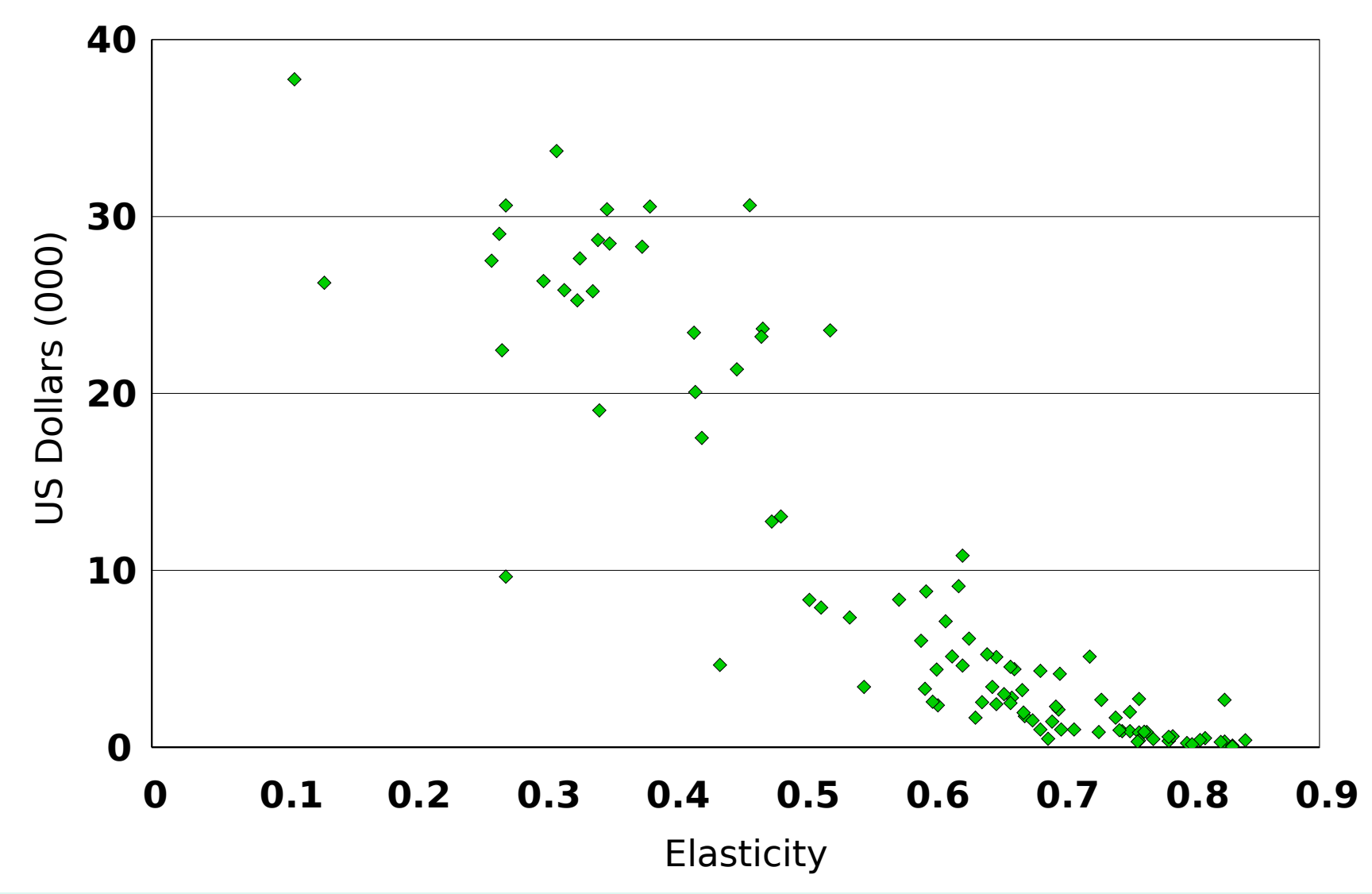
Income Elasticities for Exporting and Importing Regions

	Wheat	Corn	Soybean
S Asia	0.51	0.78	0.53
FSU-ME	0.39	0.64	0.41
SEA	0.24	0.48	0.27
Europe	0.16	0.34	0.19
Latin	0.41	0.67	0.44
S Africa	0.60	0.83	0.61
N Africa	0.41	0.66	0.44
Argentina	0.25	0.55	0.29
Australia	0.14	0.32	0.17
Brazil	0.40	0.66	0.43
Canada	0.16	0.30	0.17
Korea	0.19	0.48	0.23
Mexico	0.36	0.63	0.39
United States	0.05	0.11	0.06
Japan	0.16	0.31	0.18
China	0.44	0.73	0.47

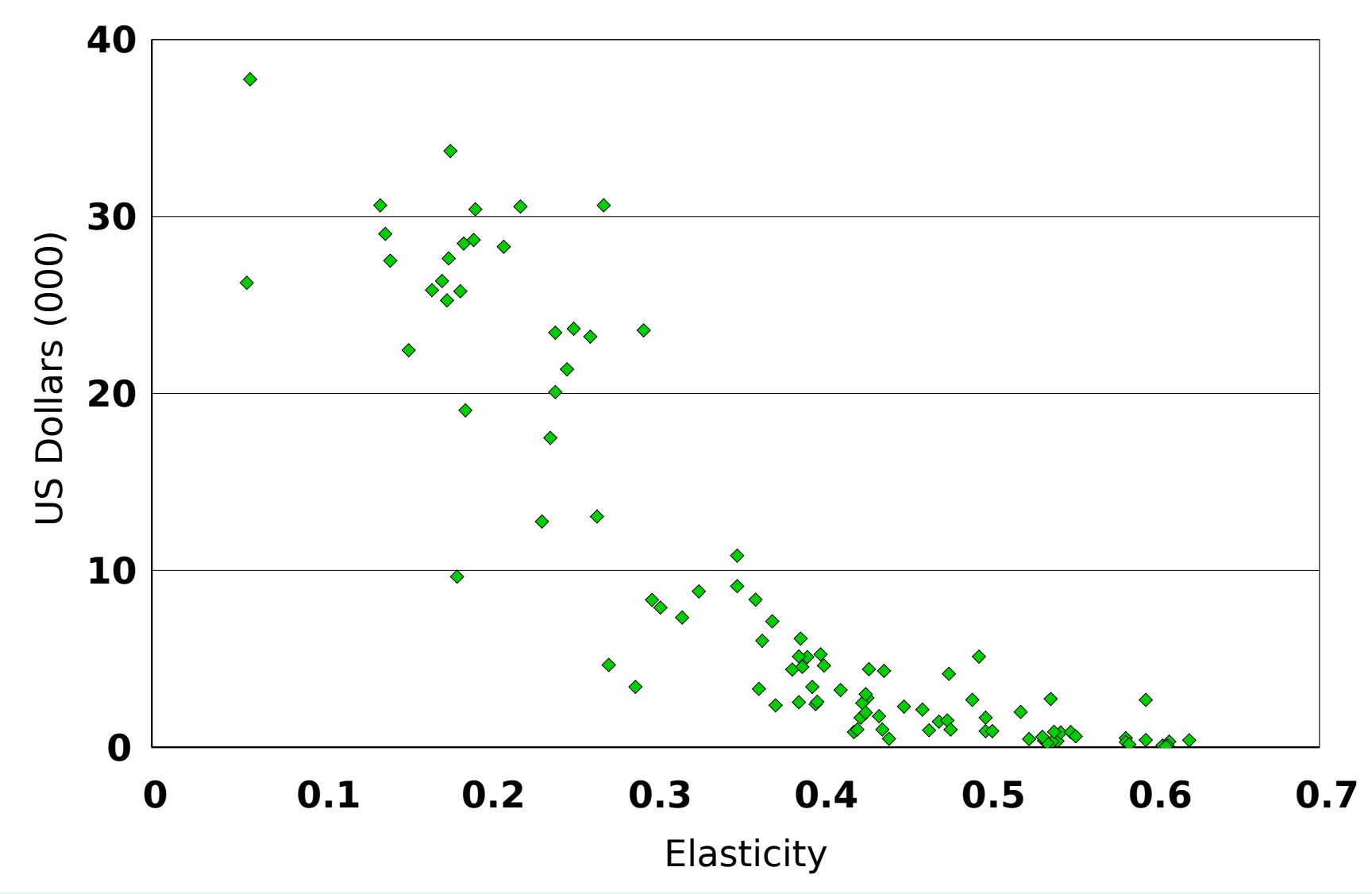
Income Elasticity for Wheat



Income Elasticity for Corn



Income Elasticity for Soybeans



Regression Results for the Income Elasticity Equations

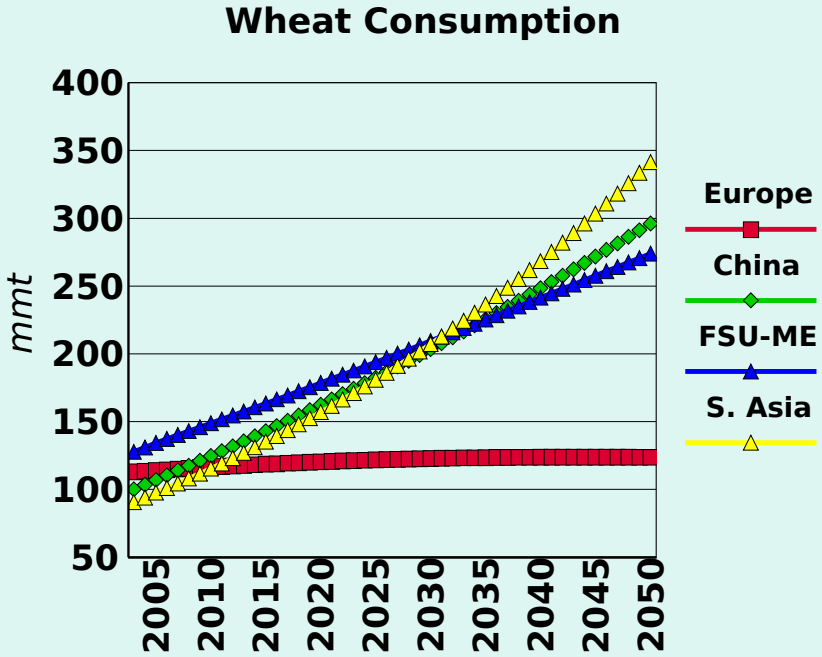
	Constant	Coefficient	R^2
Wheat	0.551	-0.078	0.846
	(9.525)	(-23.183)	
Corn	0.836	-0.096	0.862
	(12.438)	(-24.735)	
Soybean	0.574	-0.077	0.856
	(10.424)	(-24.130)	

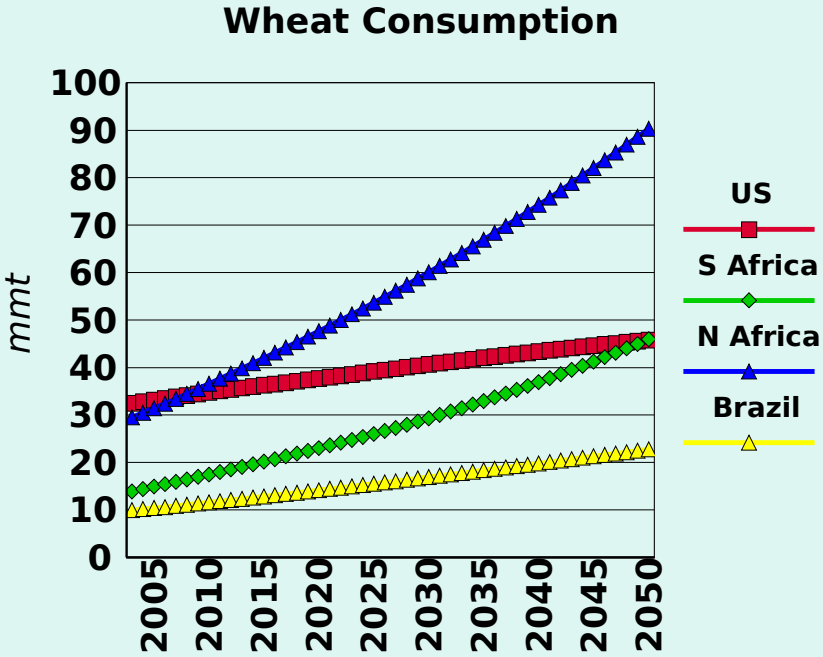
*t ratios are in ( ).

Estimated Income Elasticities for Selected Countries/Regions

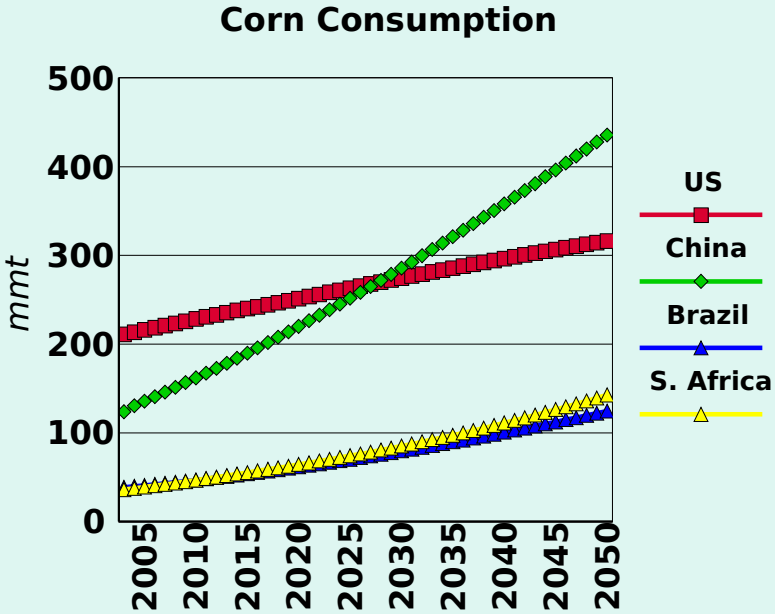
	Wheat				Corn				Soybeans			
	2003	2010	2015	2025	2003	2010	2015	2025	2003	2010	2015	2025
U. S.	0.05	0.01	-0.02	-0.08	0.11	0.06	0.02	-0.05	0.06	0.02	-0.01	-0.07
Canada	0.16	0.12	0.10	0.07	0.30	0.26	0.24	0.20	0.17	0.14	0.12	0.09
EU	0.16	0.13	0.11	0.07	0.34	0.31	0.29	0.23	0.19	0.16	0.14	0.10
Australia	0.14	0.12	0.10	0.05	0.32	0.28	0.26	0.21	0.17	0.14	0.12	0.08
China	0.44	0.42	0.41	0.37	0.73	0.71	0.69	0.64	0.47	0.45	0.44	0.40
Japan	0.16	0.12	0.10	0.04	0.31	0.26	0.23	0.16	0.18	0.14	0.11	0.06
Argentina	0.25	0.23	0.21	0.18	0.55	0.53	0.51	0.47	0.29	0.27	0.26	0.22
Brazil	0.40	0.39	0.38	0.35	0.66	0.65	0.63	0.60	0.43	0.42	0.40	0.38
Mexico	0.36	0.34	0.33	0.29	0.63	0.61	0.59	0.54	0.39	0.37	0.36	0.32
S. Korea	0.19	0.14	0.10	0.05	0.48	0.41	0.38	0.31	0.23	0.18	0.15	0.10
Latin	0.41	0.39	0.37	0.33	0.67	0.65	0.63	0.58	0.43	0.42	0.40	0.36
NAfrica	0.41	0.40	0.39	0.37	0.66	0.64	0.63	0.60	0.44	0.42	0.41	0.39
FSU-ME	0.39	0.37	0.36	0.34	0.64	0.61	0.60	0.57	0.41	0.40	0.38	0.36
SAfrica	0.60	0.59	0.59	0.58	0.83	0.82	0.82	0.81	0.61	0.60	0.60	0.59
SAsia	0.51	0.50	0.49	0.48	0.79	0.78	0.77	0.75	0.53	0.52	0.52	0.50
SEA	0.24	0.23	0.22	0.19	0.48	0.46	0.45	0.42	0.27	0.26	0.25	0.22

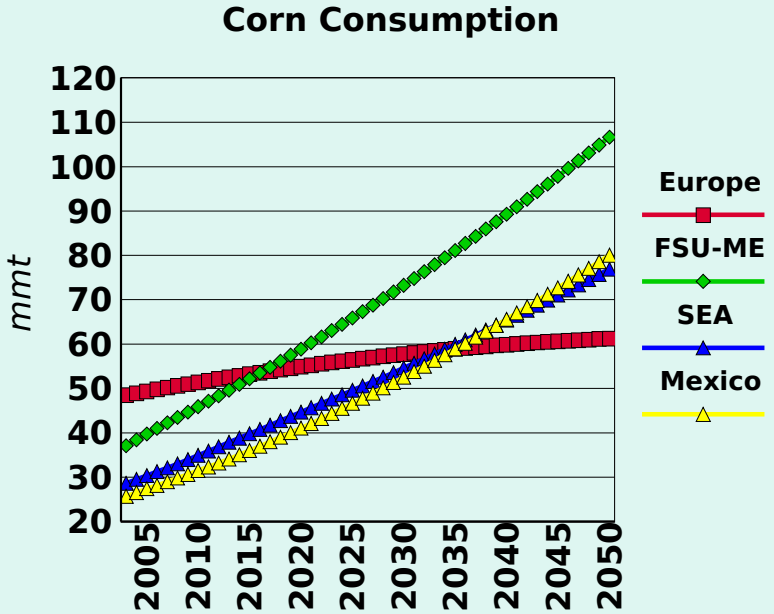
Wheat: Forecast Consumption, Selected Countries/Regions, 2005-2050



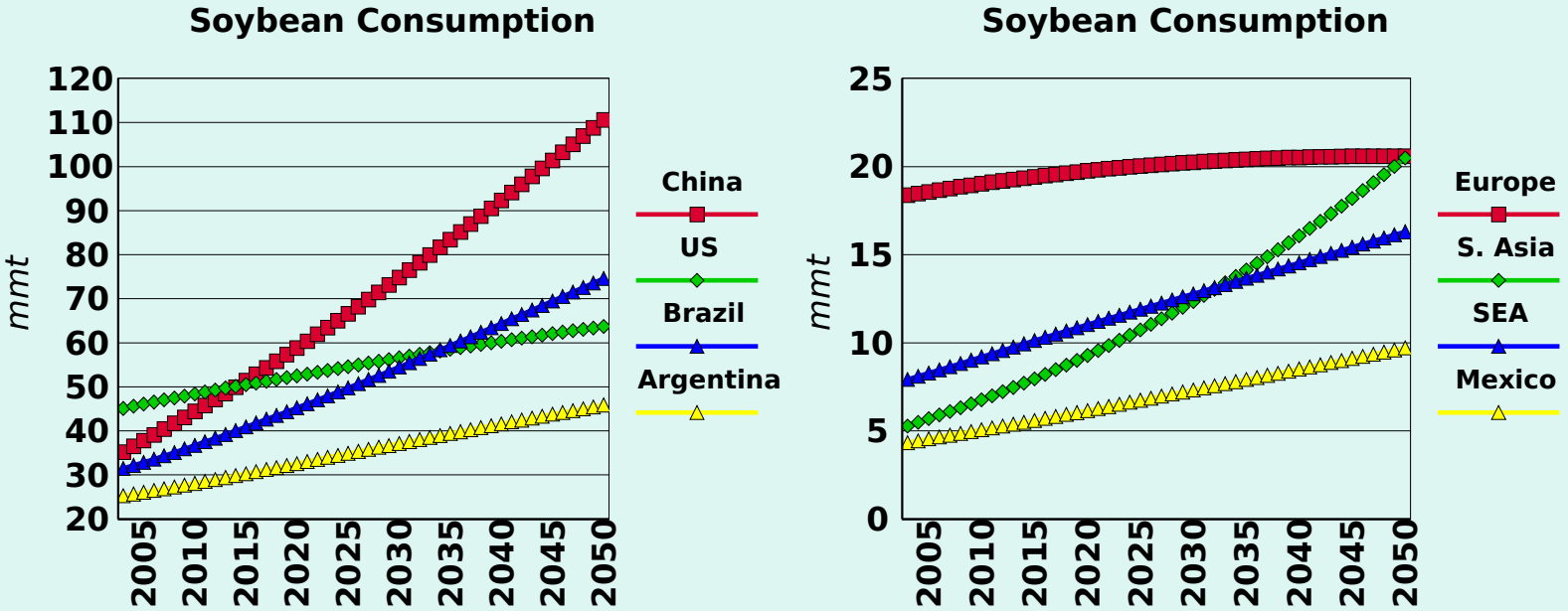


Corn: Forecast Consumption, Selected Countries/Regions, 2005-2050





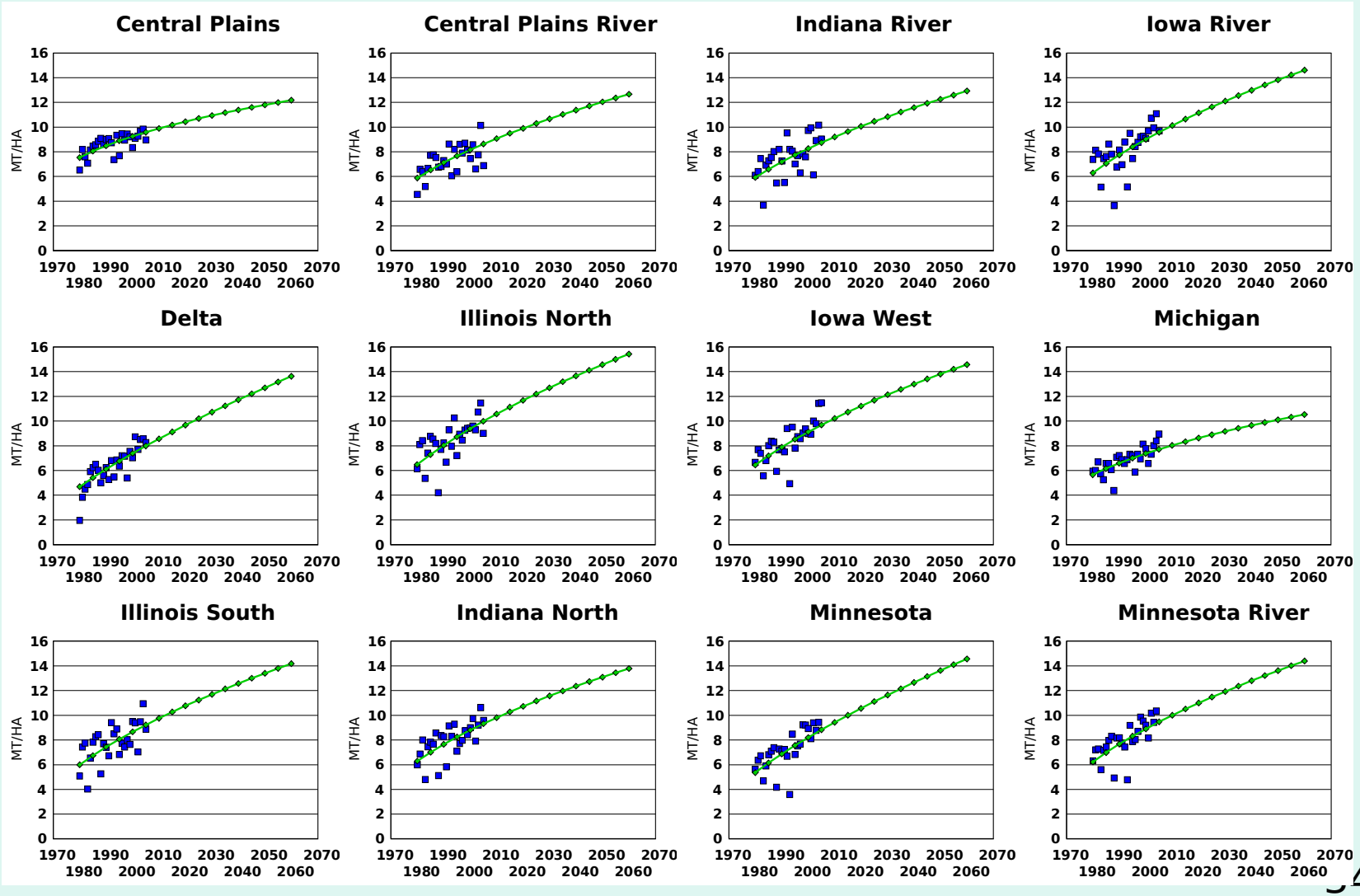
Soybean: Forecast Consumption, Selected Countries/Regions, 2005-2050



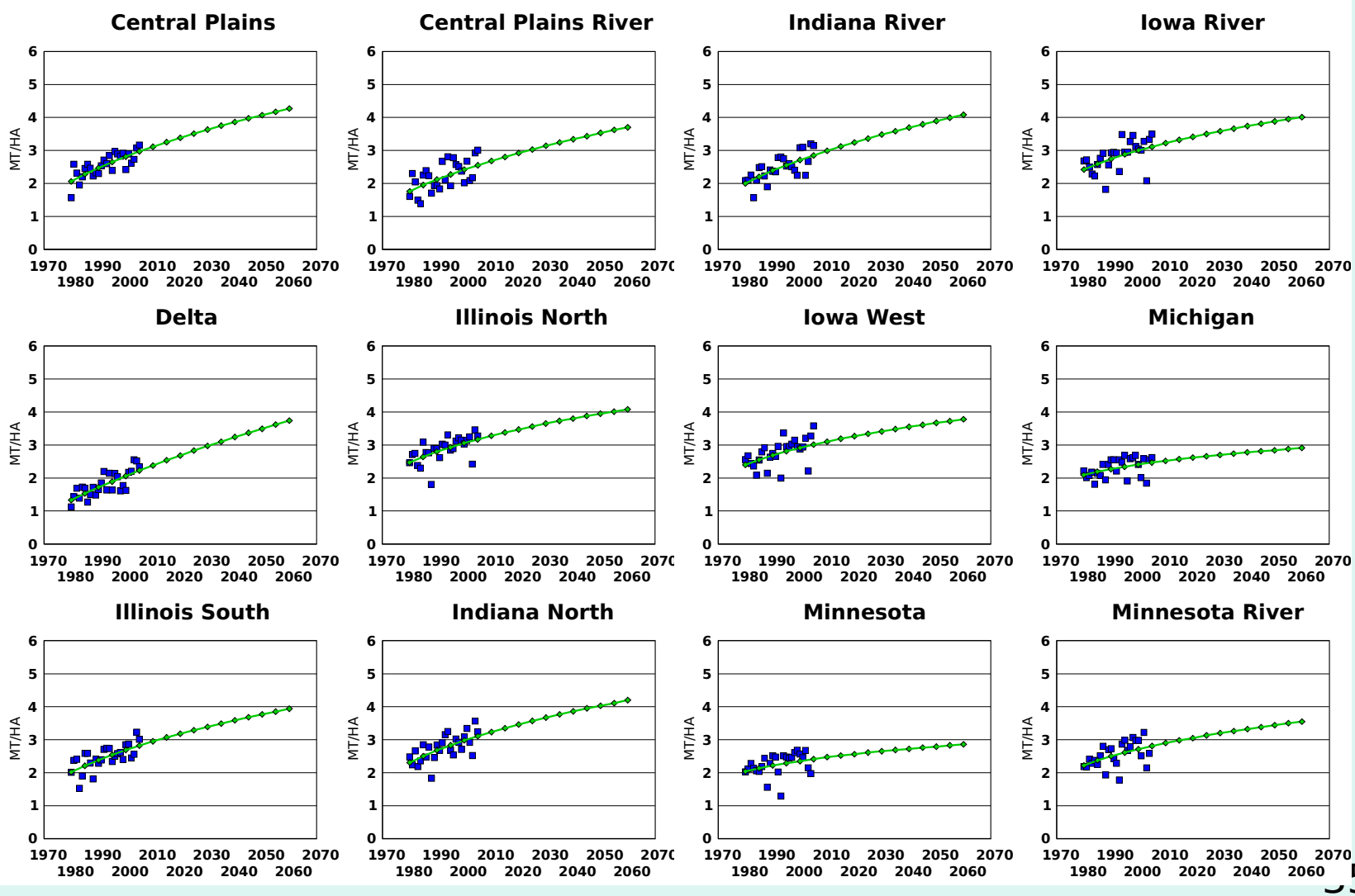
Grain/Oilseed Production Cost

- Data from *Global Insights*
  - By country and crop
  - Standardized method to derive variable costs/HA
- Combined with estimated yields to derive costs in $/mt
  - By crop
  - By country/region
  - Projections

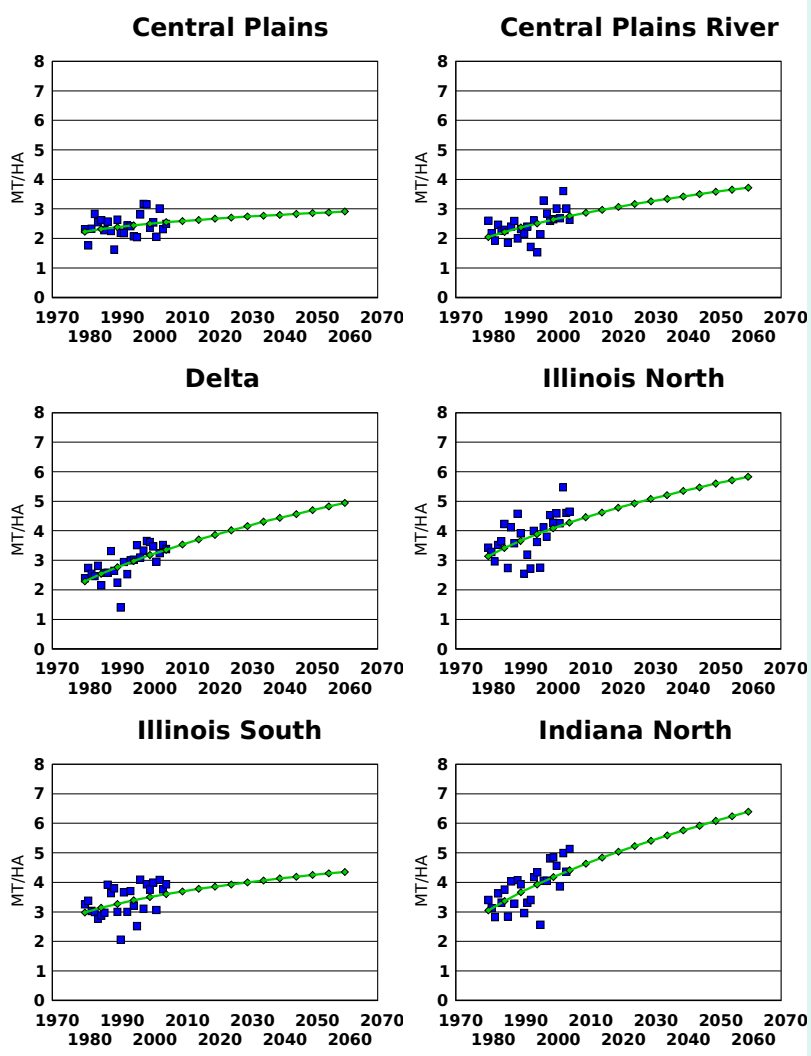
US Corn Yields (Actual vs Predicted)

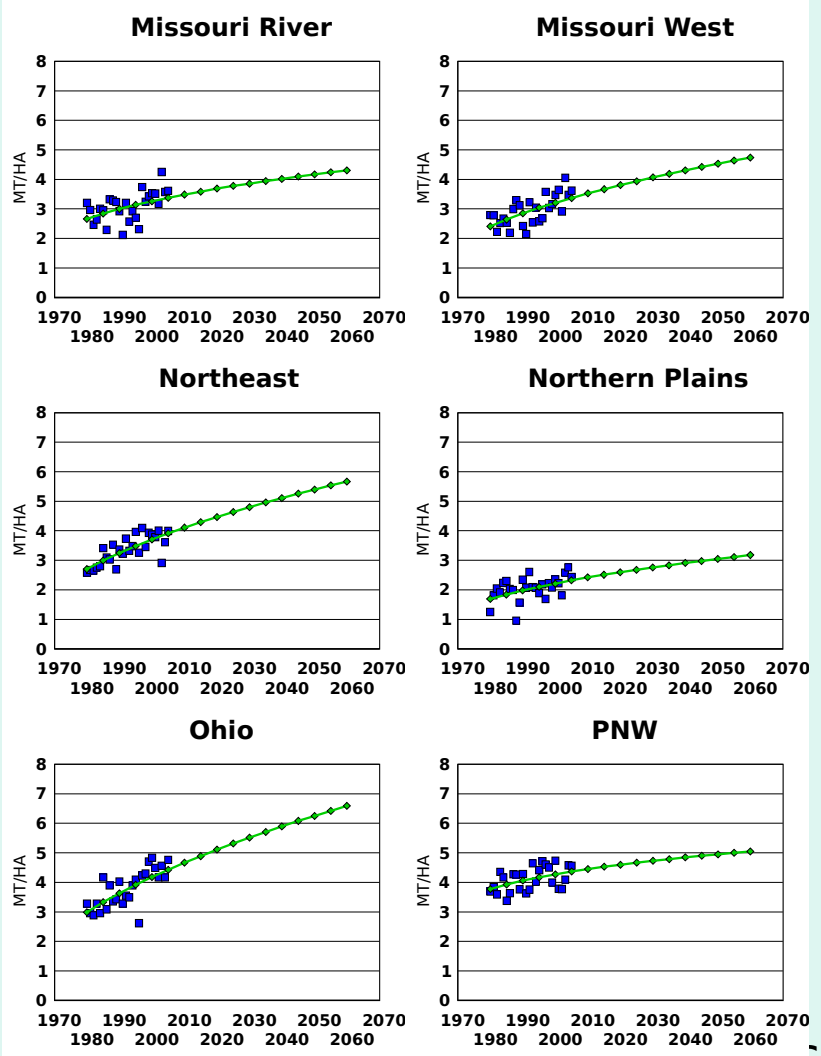


US Soybean Yields (Actual vs Predicted)



US Wheat Yields (Actual vs Predicted)

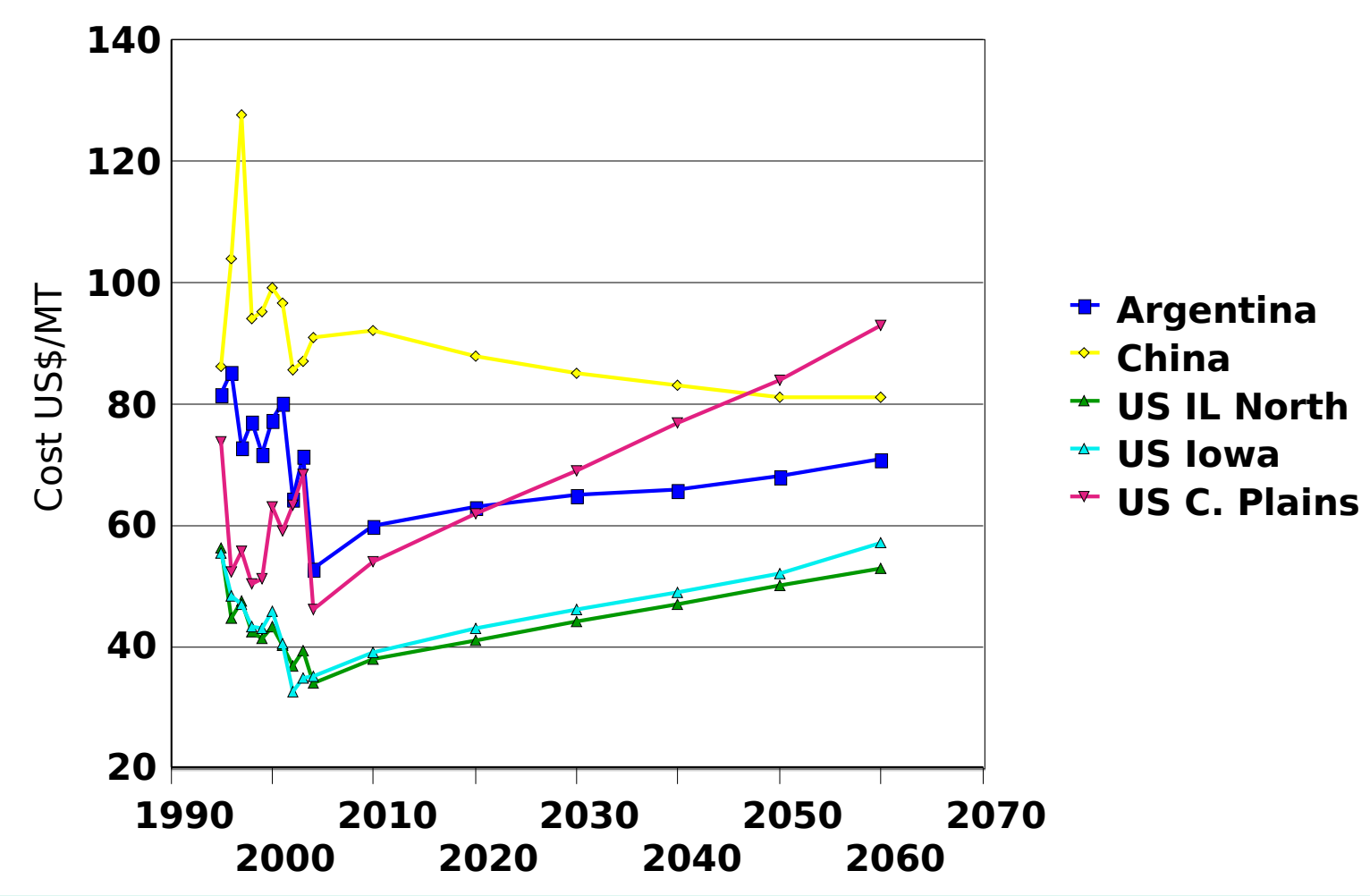




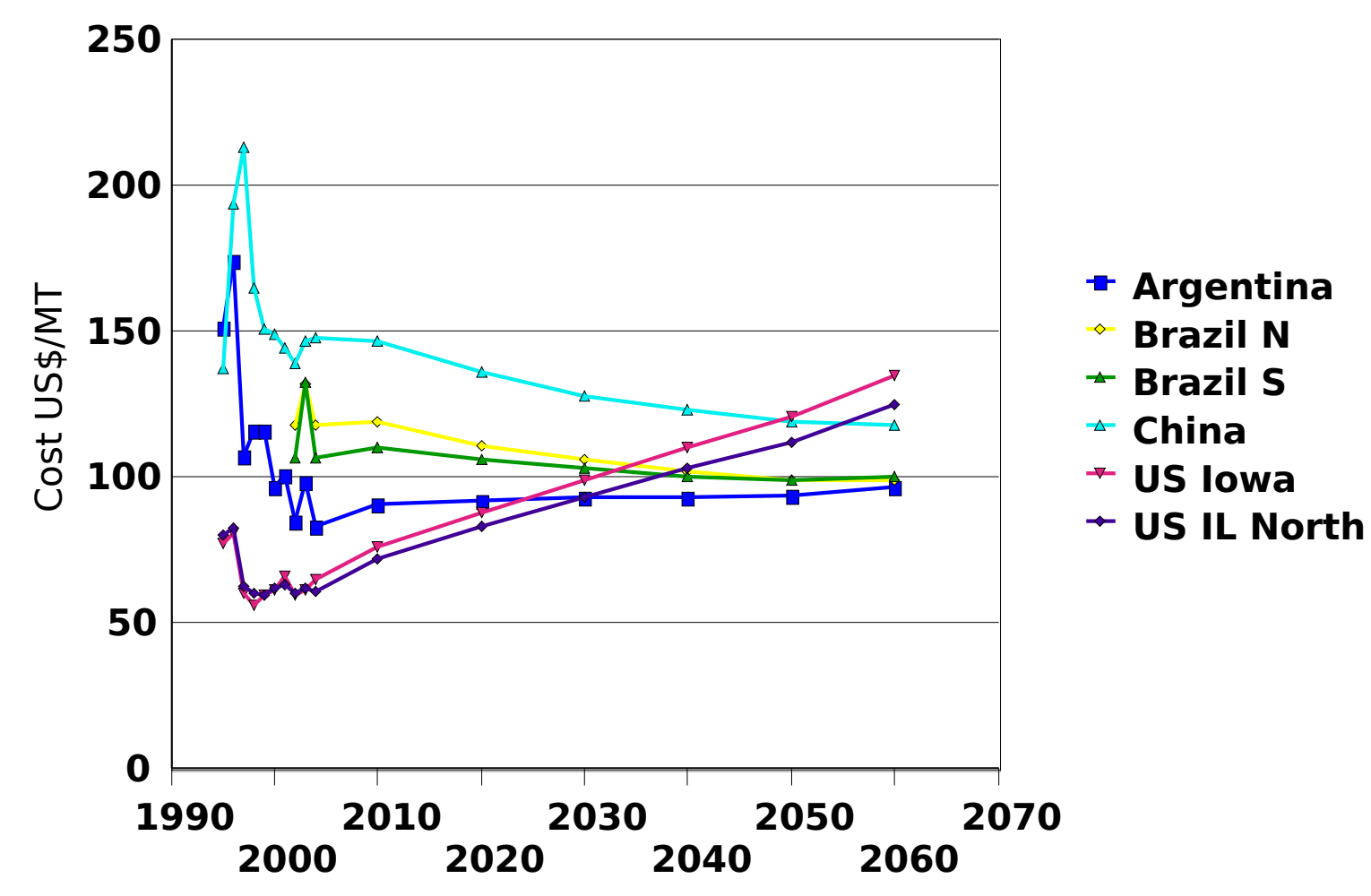
Cost advantage for U.S. producing regions diminishes over time

- Increases in production costs for U.S. regions rise at similar rates to that for major competing exporters.
- The rate of increase in yields in US is less (slightly) than competing exporters.
  - In competing countries, the rate of increase in yields is comparable to that of production costs.
  - In the United States, yield increases are less than competing exporters'; and, are less than production cost increases.
- The impact of these is very subtle, but, when extrapolated forward, results in a changing competitive position of the United States relative to competing countries.

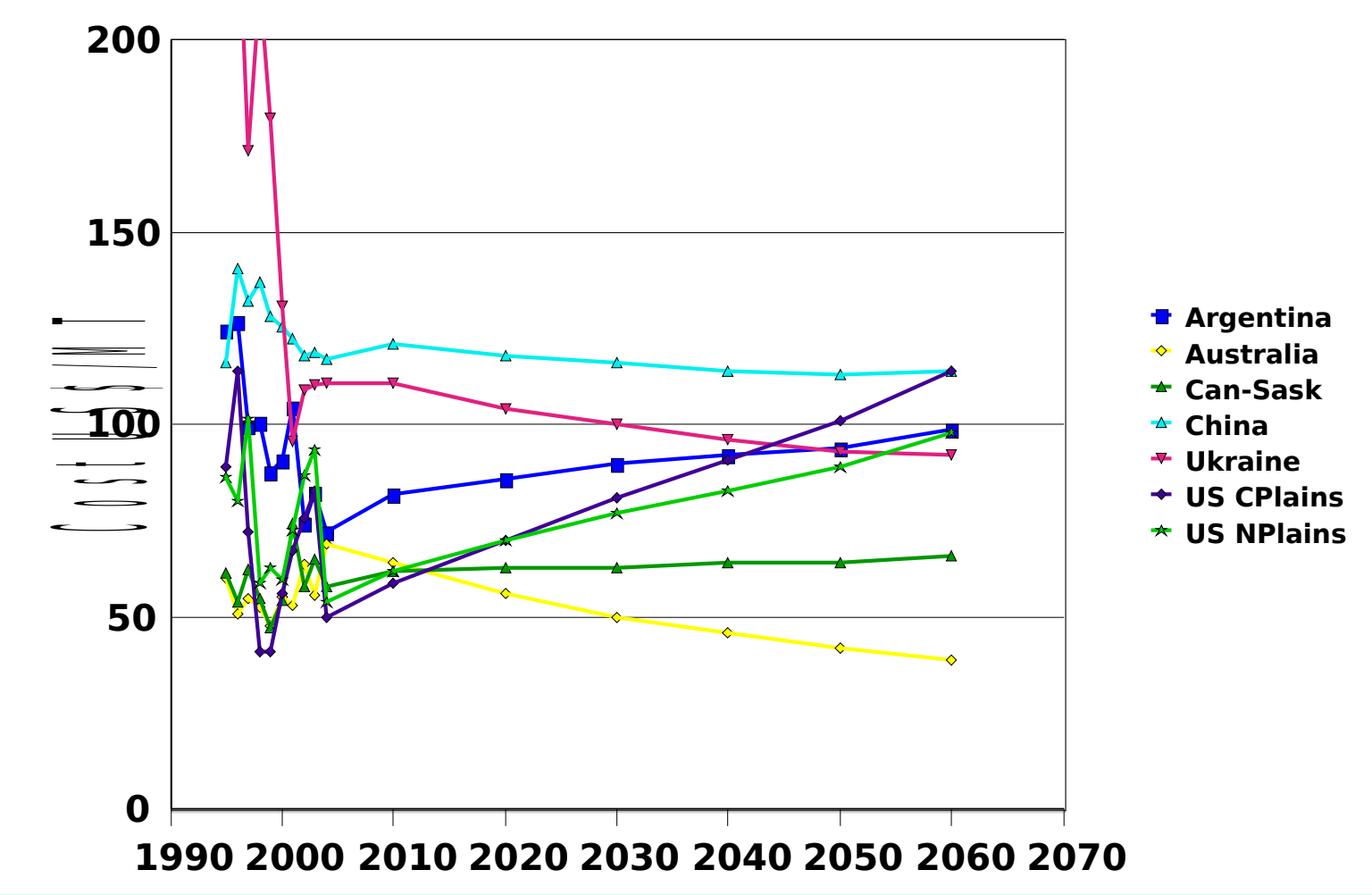
Corn Cost of Production ($/mt)



Soybean Cost of Production ($/mt)



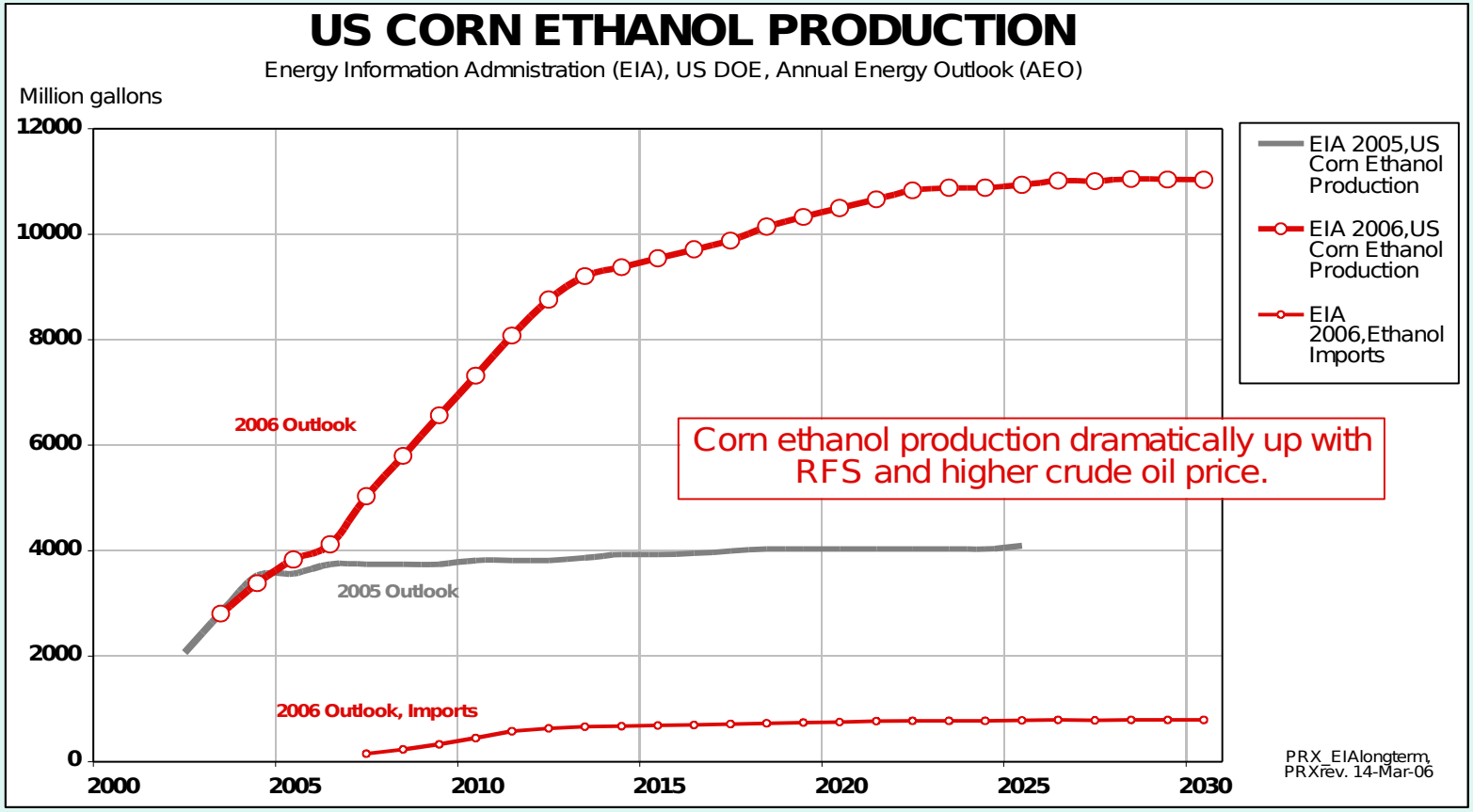
Wheat Cost of Production ($/mt)



Ethanol

- Projections and sensitivities
  - EIA 2005 was the base case
  - EIA 2006 assumption (Ethanol sensitivity)
  - Qualified alternative stylized assumptions
- Method
  - Current known demand: Assumed
  - New demand:
    - Allocated proportionately across states
  - DDGs produced
    - returned to regional feed demand proportionate to its value

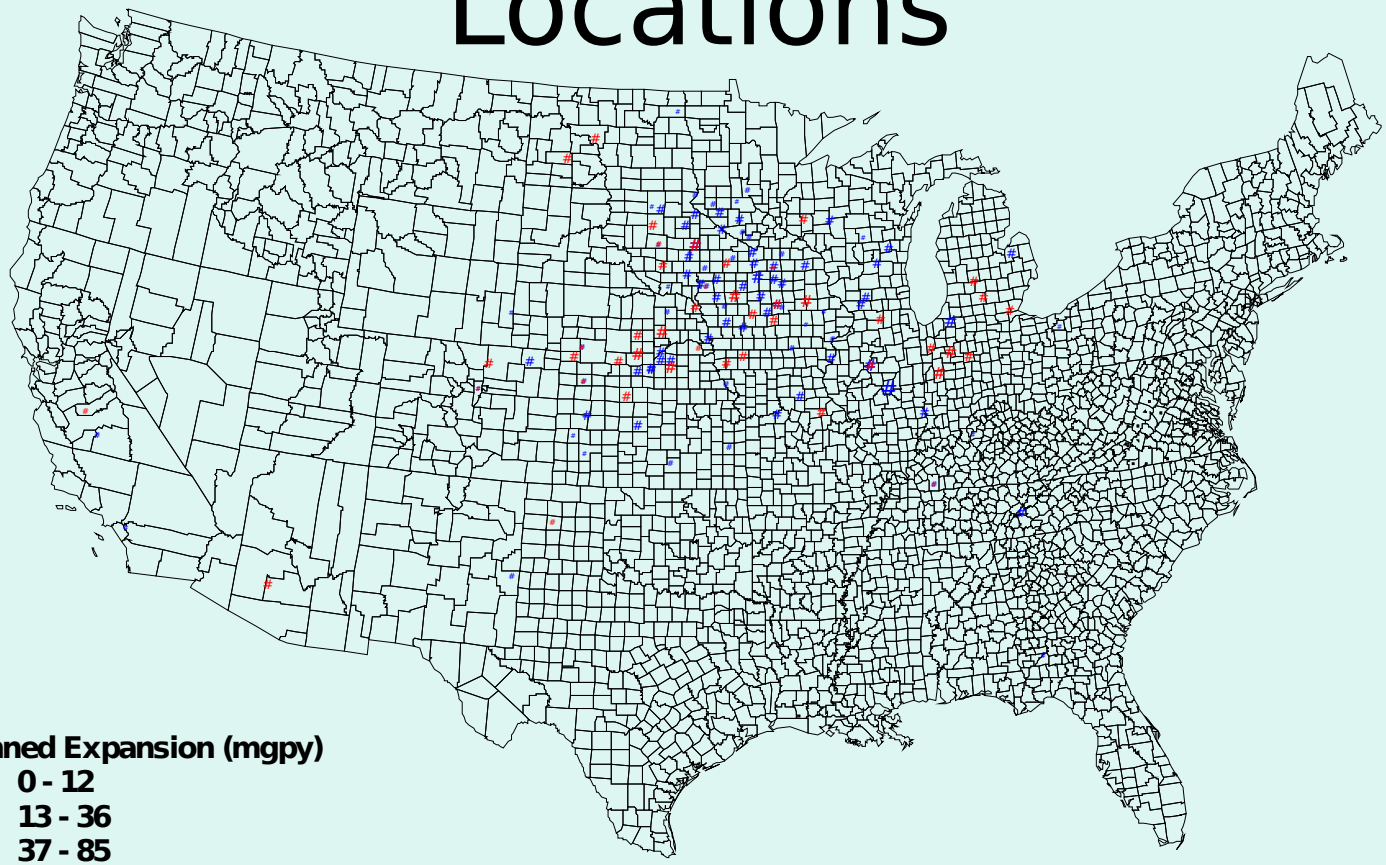
EIA Corn Ethanol Forecast 2006



According to the EIA:

"Higher oil prices increase the demand for unconventional sources of transportation fuel, such as ethanol and biodiesel, and are projected to stimulate coal-to-liquids (CTL) production in the reference case. . . . The production of alternative liquid fuels is highly sensitive to oil price levels."

May 2006 Ethanol Plant Locations



May 2006 Ethanol Plant Locations

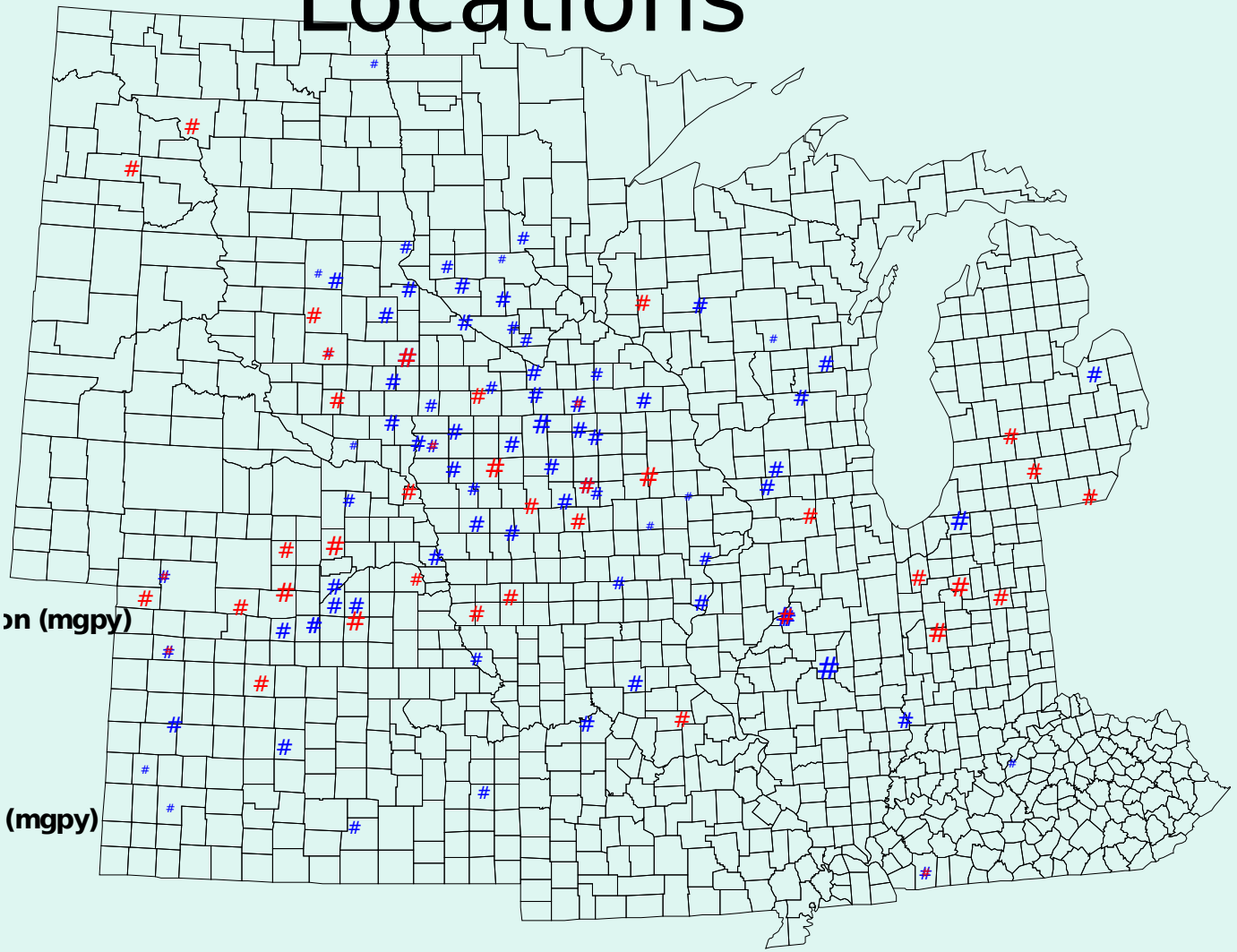


Table 3.1 Percent of U.S. Consumption by Crop and Region, 2003-2005.

Region	Total Corn Demand	Corn Demand for Ethanol Use	All Other Demand
US Central Plains	14%	17%	13%
US Delta	4%	0%	5%
US Eastern Corn Belt	21%	26%	21%
US North East	5%	0%	6%
US Northern Plains	4%	12%	2%
US Pacific North West	2%	0%	2%
US South East	15%	2%	17%
US Southern Plains	8%	0%	9%
US Western Corn Belt	24%	42%	20%
US West	4%	0%	5%

Newly announced plants (July 2006)

- Illinois:
  - 7 plants and 30 in various planning stages
- Iowa:
  - 24 operating units in Iowa
- Nebraska:
  - 12 plants and about 22 in planning stages
- North Dakota : 4 projects underway
  - Hankinson, Red Tail Energy, Spiritwood Underwood and Williston (announced in Williston on July 7, 2006).

Plans for new plants and expansions continue to change

- Iowa exported 803 million bushels in 2003, but by 2008 would be deficit 400-500 million bushels with existing plants running at rated capacity (Wisner);

- ProExporter estimates were 5.3 billion gallons of capacity currently operating, and another 6 billion under construction.
  - There were an additional 369 projects on the drawing boards representing an additional 24.7 bill gallons of ethanol capacity (as Ethanol margins in 2005 was 152 c/bu of corn processed and this has declined to 44 c/bu this year, and this was more than attractive to justify additional investment.
- Goldman Sach expressed worry about high corn prices indicating that rising corn prices threaten profitability of ethanol. Biomargins have been hurt by 55% increase in corn price and price of ethanol has risen by 8%. Without producer incentives and tax credits Goldman believes many biofuel plants would be unprofitable.

ProExporter Blue-Sky Model

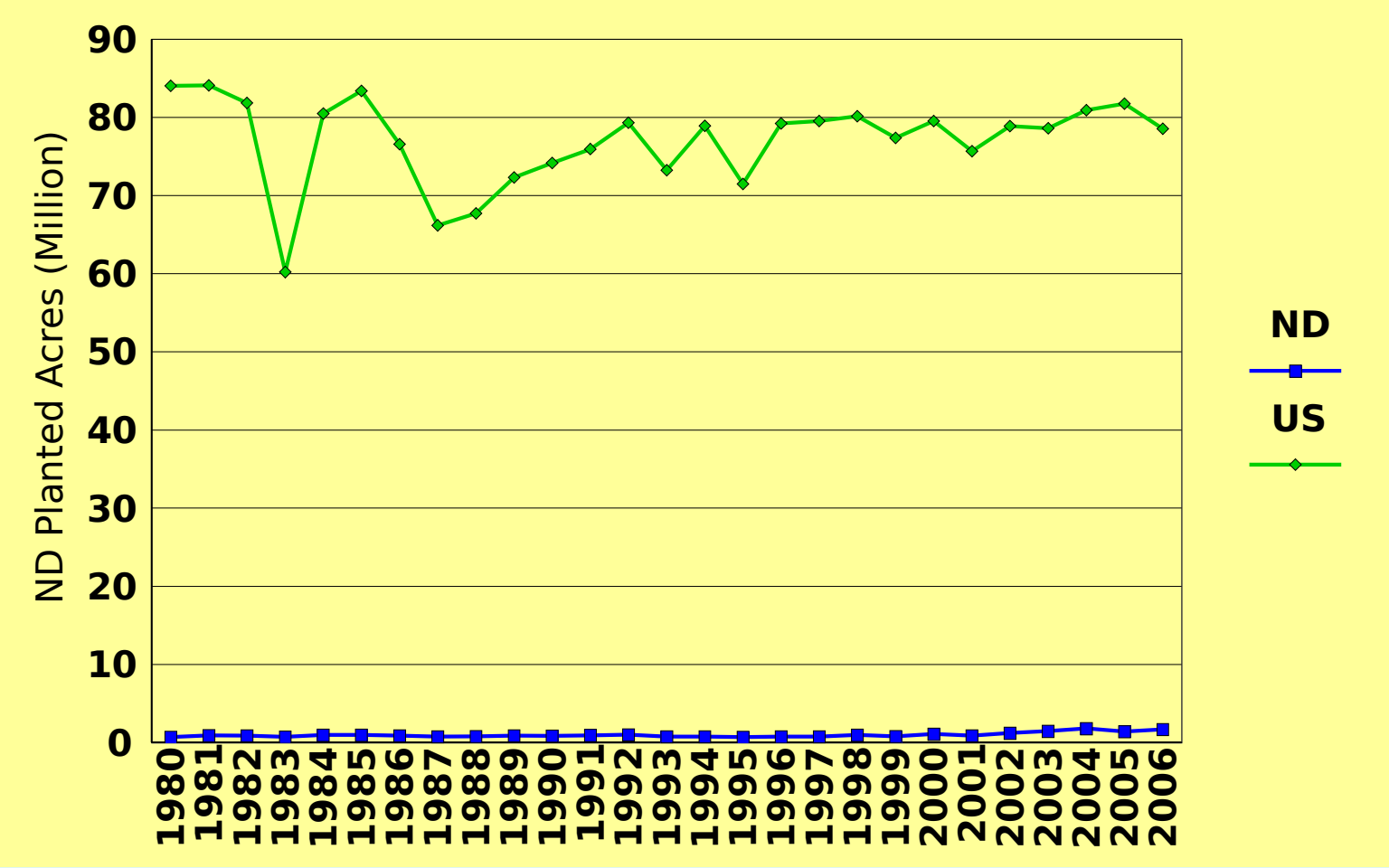
- Longer term
  - Ethanol use would converge to 18.7 billion gallons
  - In the US
    - Corn production would be
    - Exports would be
- Origination wars in Minnesota, Iowa and Nebraska as shuttle shippers for feed to California and the Southwest, and the PNW have to compete with ethanol.
  - Due to superior margins in ethanol, the latter would set the price and force others to pay more.

CARD/ISU Study

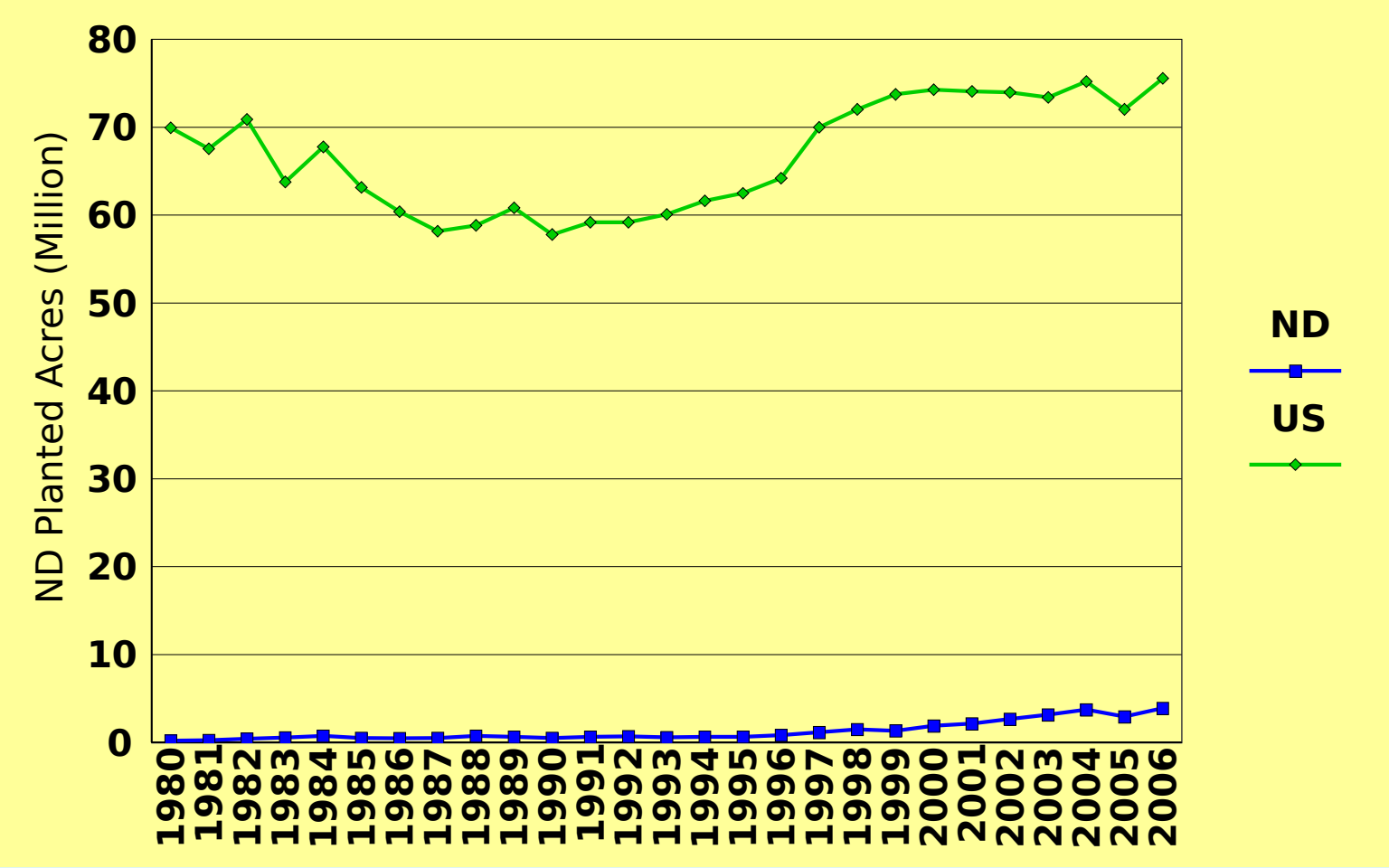
- Results indicated the break-even corn price is 405c/b.
- Corn based ethanol would increase to 31.5 bill gal by 2015.
- U.S. would have to plant 95.6 million acres of corn (vs. 79 million in 2006) and produce 15.6 bill bush (vs. 11 billion today).
- Most of the acres would come from reduced soybean acreage.
  - There would be a 9 million-acre reduction in soybean area
  - a change in rotation from corn-soybean to corn-corn-soybean.
- Corn exports would be reduced substantially and suggested the U.S. could become a corn importer.

- Finally, wheat prices would increase 20%
  - there would be a 3% reduction in wheat area with wheat feed use increasing
  - Wheat exports decline 16 percent.

Corn Planted Acres



Soybean Planted Acres



What was concluded?

- If the prices of crude oil, natural gas, and DDGs stay at current levels (crude=60$), the corn price will converge to 405c/b.
- At this price
  - corn based ethanol would reach 31.5 bill gal/yr
    - This is concerning because RFS is pointing to 7.5 bill gal nearby and 12 billion by 2015 and Blue-Sky Proexporter gets to about 17 bill gal.
  - corn area would increase to 95.6 mill ac planted
  - Corn production would increase to 15.6 bill bu vs. 11 today
  - Soybean acres would decline to 59 mill
  - Wheat not change radically, and would would adjust to for feeding purposes
- Corn exports would decline;
  - once US ethanol reaches about 22 bill gallons, the US will no longer export corn; and,
  - could become an importer of corn.

Yields, CRP and the ability to increase production:

- Wisner and Hurd.
  - caution on the potential to shift enough acres to corn to accommodate growth in ethanol, the prospects of a drought and concerns for the draw-down in stocks.
  - increase in corn acres to meet these demands would be in the area of 11-12 million acres of corn by 2012, and, if China were an importer this would be 14 million acres.
  - Added planted area could be taken from soybeans, other small grains or from the Conservation Reserve Program (but, with a majority coming from soybeans).
  - Corn supply crunch was on and the impacts of these will be reduced stocks after which each marketing year will be fraught with uncertainties about supplies.
- Yield and CRP discussed separately

Yields: the ability to increase production

- Schlicher indicated

"Improvements in corn yields and the ethanol process will allow the number of gallons of ethanol produced per acre to increase from 385 gal in 2004 to 618 gal by 2015.

The historical average annual corn yield increase was 1.87 b/a; and is now averaged at 3.14 b/ac over the past 10 years...which shows the impact of ag biotech."

...with such improvements, she said, 10% of the country's gasoline can come from corn ethanol within a decade without sacrificing corn use elsewhere.

Yields and the ability to increase production

- Meyer indicated that

  corn yields in past 10 years have increased from 126 b/a in 1996 to a projected 153 b/a in 2006. The gains substantially over trend line per year are possible due to genetic modification as these adopted by growers. Stacking of traits in the next 3-5 years could result in corn production in 14-15 bill bu per year on the same acres as 1996.

Yield Technology Potential

- National Corn Growers Association indicated
  - ...*We can easily foresee a 15 billion corn crop by 2015…That's enough to support production of 15 to 18 billion gallons of ethanol per year and still supply the feed industry and exports, with some room for growth.* (as reported by Zdrojewski, 2006).
  - Attributed to prospective advances in corn genetics and some acreage increase.
- They indicated
  - historic yield trends by 2010 would be 162 b/a and 173 by 2015.
  - Planted area would need to be about 90 million acres, up from 71 this year, which would be the highest plantings on record (the previous high was 75 million acres in 1986).
  - The difference would come from CRP.

Fraley on Yield Technology Potential

- Corn yields double in 25 years, reaching 300b/a in 25 years which was a reasonable goal.
  - New technology includes traits influencing
    - Yields
    - drought tolerance
      - Yields on dryland conditions could increase 8-10%.
    - fertilizer use
    - pest resistance.
    - redesign of corn to increase starch content
      - Increase from 2.8 to 3.0 gall/b
  - With this, he indicated it would be possible to increase ethanol production to 50 bill gallons, based on a corn crop of 25 bill bushels from 90 million acres in 2030.

Monsanto's GM Corn Pipeline

Trait	Phase	Scope	Yield Impact
Nitrogen Utilizing Corn	1 Proof of Concept (8+ years; Prob=.25)	Increase in yield on limited nitrogen environments; 10% target yield increase	10%
Drought tolerant corn	II Early Development (5+ years; Prob=.50)	Under drought stress, hybrids with best performing events show yield advantage; allows expansion of corn areas to more dry regions (western dryland, 10-12 m acres)	8%
High yielding corn	I Proof of concept (8+ years; Prob=.25)		
High fermentable corn		Increase from 2.8 gall/b; 2.7% increase in ethanol yields (2.87 gall/b)	
Renessen corn processing system	4 Regulatory submission (3+ years; Prob=.90)	Pre-processing to produce higher value co-products and higher fermentable starch for ethanol. Combined with high-lysine products to improve quality and reduces the amount of DDGs	

Cautions on Yield Growth Rates

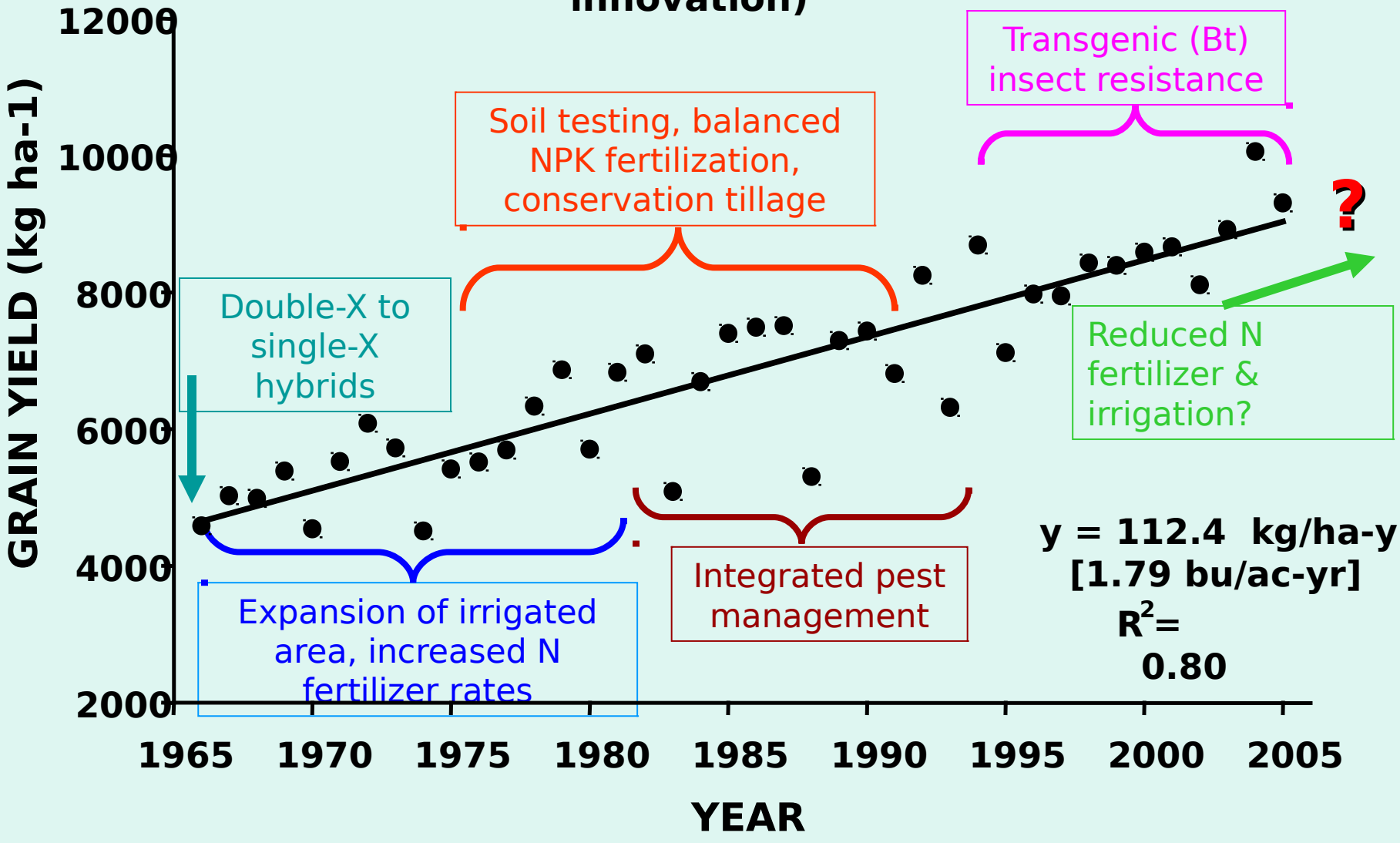
- GM Proposed traits are under development
  - Prob of being commercialized<1
  - Uncertainty on
    - technical efficiency
    - regulatory approval
- Traits unlikely to be fully adopted
- Other
  - Reduced yields on increased area
  - Reduced yields on more intense rotations

GM crops productivity

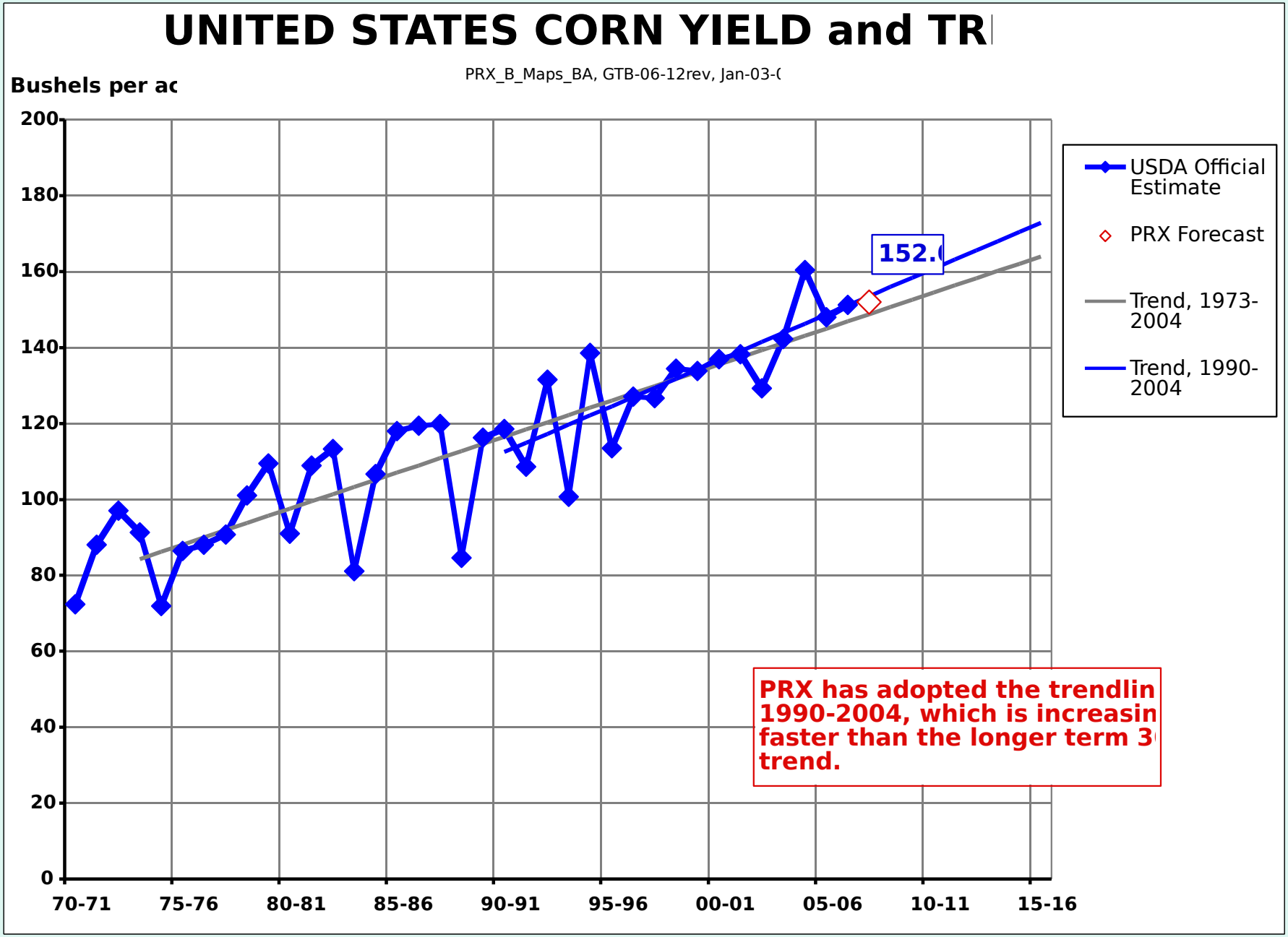
- Issue:
  - lots of discussion/opinions of the prospect for increased yields due to GM crops.
- Interpretation:
  - Short term trends vs. longer term trends; and, slope of yield function
- Implicit assumption
  - Assume yields grow at trend rates reflecting technology growth over the sample period; and, that this will persist
  - It does not account for
    - Potential breakthroughs in new technology other than would be reflected in current growth rates
    - Adoption of other bio-fuel crops—switchgrass

USA Corn Yield Trends, 1966-2005

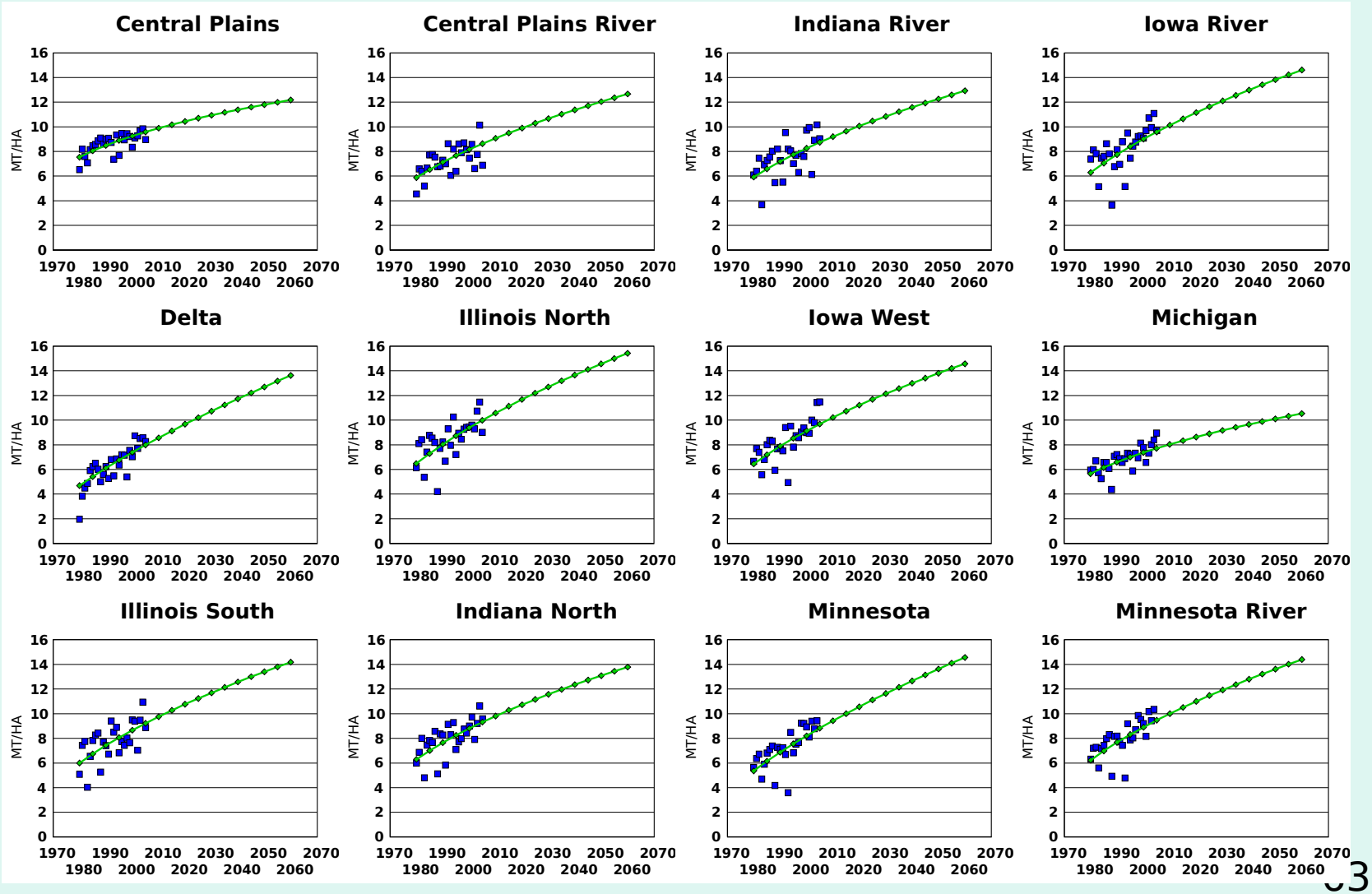
(embodies tremendous technological innovation)



K.G. Cassman, CAST Renewable Energy Agriculture, In Press.


UNITED STATES CORN YIELD and TR
PRX_B_Maps_BA, GTB-06-12rev, Jan-03-(
Bushels per ac
200
180
160
140
120
100
80
60
40
20
0
70-71
75-76
80-81
85-86
90-91
95-96
00-01
05-06
10-11
15-16
USDA Official Estimate
PRX Forecast
Trend, 1973-2004
Trend, 1990-2004
152.(
PRX has adopted the trendlin
1990-2004, which is increasin
faster than the longer term 3
trend.

US Corn Yields (Actual vs Predicted)



Yield Forecast Comparisons

- Shift due to adoption of GM varieties
- Adoption levels in corn for biotech varieties started in 1996
  - 25% in 2000.
  - less than 50% of planted area until 2005

USDA-NASS Biotech Corn Variety Adoption

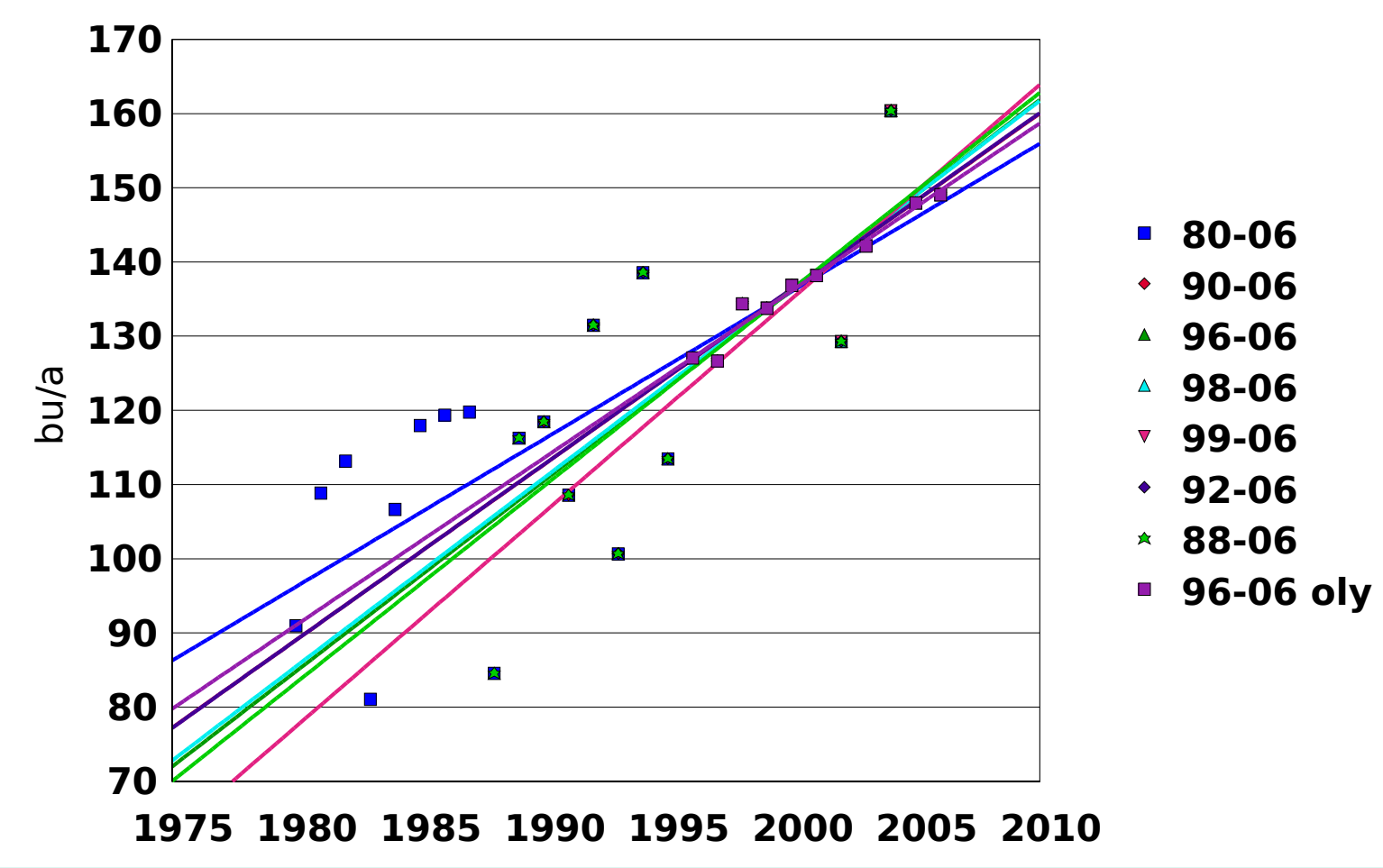
Genetically engineered (GE) corn varieties by State and United States, 2000-2006														
	Insect-resistant (Bt) only							Herbicide-tolerant only						
State	2000	2001	2002	2003	2004	2005	2006	2000	2001	2002	2003	2004	2005	2006
	Percent of all corn planted							Percent of all corn planted						
Illinois	13	12	18	23	26	25	24	3	3	3	4	5	6	12
Indiana	7	6	7	8	11	11	13	4	6	6	7	8	11	15
Iowa	23	25	31	33	36	35	32	5	6	7	8	10	14	14
Kansas	25	26	25	25	25	23	23	7	11	15	17	24	30	33
Michigan	8	8	12	18	15	15	16	4	7	8	14	14	20	18
Minnesota	28	25	29	31	35	33	28	7	7	11	15	17	22	29
Missouri	20	23	27	32	32	37	38	6	8	6	9	13	12	14
Nebraska	24	24	34	36	41	39	37	8	8	9	11	13	18	24
North Dakota 1/						21	29						39	34
Ohio	6	7	6	6	8	9	8	3	4	3	3	4	7	13
South Dakota	35	30	33	34	28	30	20	11	14	23	24	30	31	32
Texas 1/						21	27						42	37
Wisconsin	13	11	15	21	22	22	22	4	6	9	9	14	18	18
Other States 2/	10	11	14	17	19	19	20	6	8	12	17	21	19	25
U.S.	18	18	22	25	27	26	25	6	7	9	11	13	17	21
	Stacked gene varieties							All GE varieties						
State	2000	2001	2002	2003	2004	2005	2006	2000	2001	2002	2003	2004	2005	2006
	Percent of all corn planted							Percent of all corn planted						
Illinois	1	1	1	1	2	5	19	17	16	22	28	33	36	55
Indiana	*	*	*	1	2	4	12	11	12	13	16	21	26	40
Iowa	2	1	3	4	8	11	18	30	32	41	45	54	60	64
Kansas	1	1	2	5	5	10	12	33	38	43	47	54	63	68
Michigan	*	2	2	3	4	5	10	12	17	22	35	33	40	44
Minnesota	2	4	4	7	11	11	16	37	36	44	53	63	66	73
Missouri	2	1	2	1	4	6	7	28	32	34	42	49	55	59
Nebraska	2	2	4	5	6	12	15	34	34	46	52	60	69	76
North Dakota 1/						15	20						75	83
Ohio	*	*	*	*	1	2	5	9	11	9	9	13	18	26
South Dakota	2	3	10	17	21	22	34	48	47	66	75	79	83	86
Texas 1/						9	13						72	77
Wisconsin	1	1	2	2	2	6	10	18	18	26	32	38	46	50
Other States 2/	1	1	2	2	6	6	10	17	20	27	36	46	44	55
U.S.	1	1	2	4	5	9	15	25	26	34	40	45	52	61

* Less than 1 percent.
1/ Estimates published individually beginning in 2005.
2/ Includes all other States in the corn estimating program.

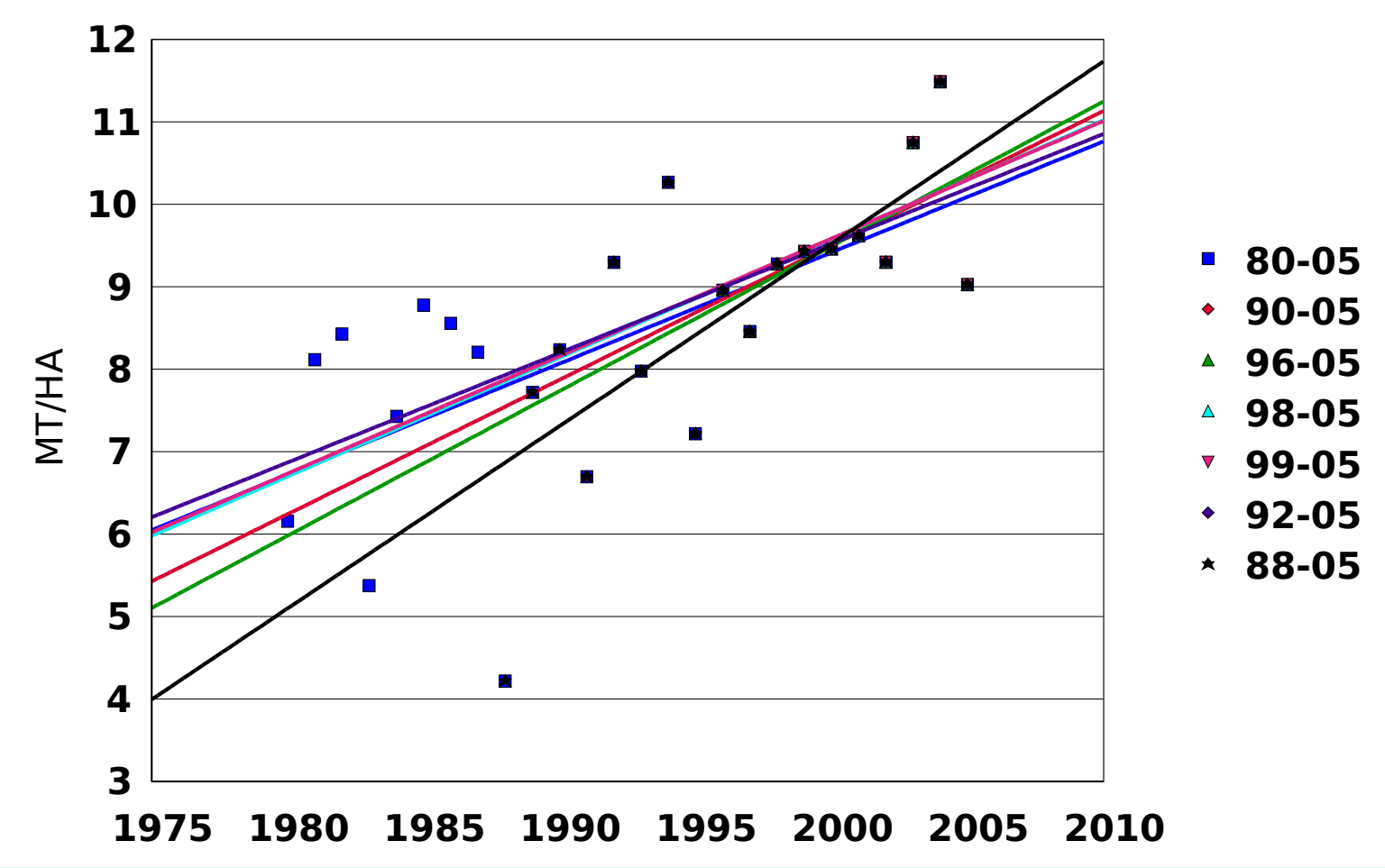
Yield Forecast and Data Interrogation

- Regression covered period 1980-2005 and were for production regions
- Regressed
  - linear and double log models
  - yield = f(trend) + binary (1995 -)
  - log yield = f (log trend) + binary (1995 -)
  - to test statistical significance of shift in trend of growth of corn yields
- In all cases estimated parameter for either slope or intercept binary effects was not statistically significant at p=.95

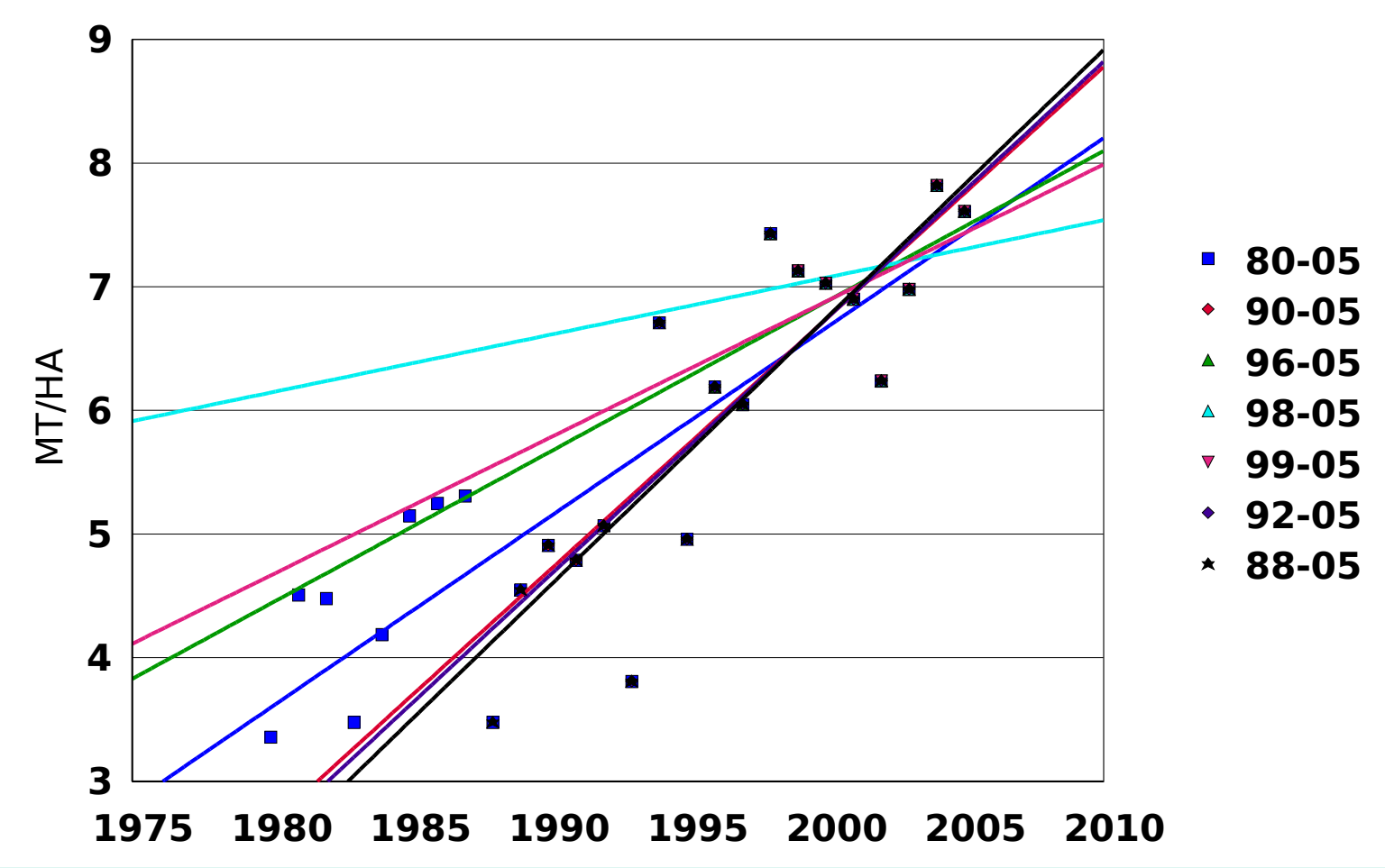
U.S. Corn Yield Trends Over Selected Time Periods



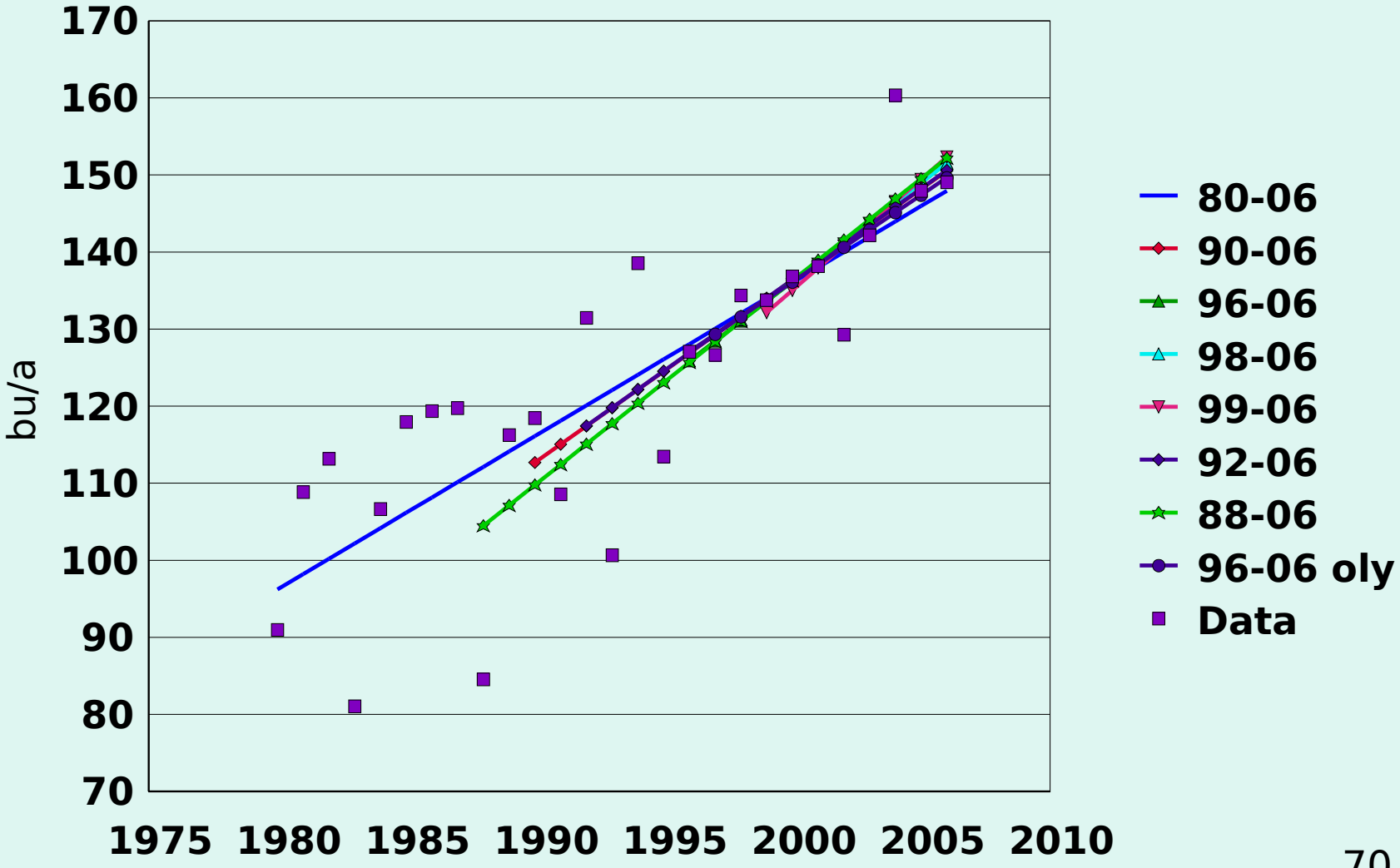
Northern Illinois Corn Yield Trends Over Selected Time Periods



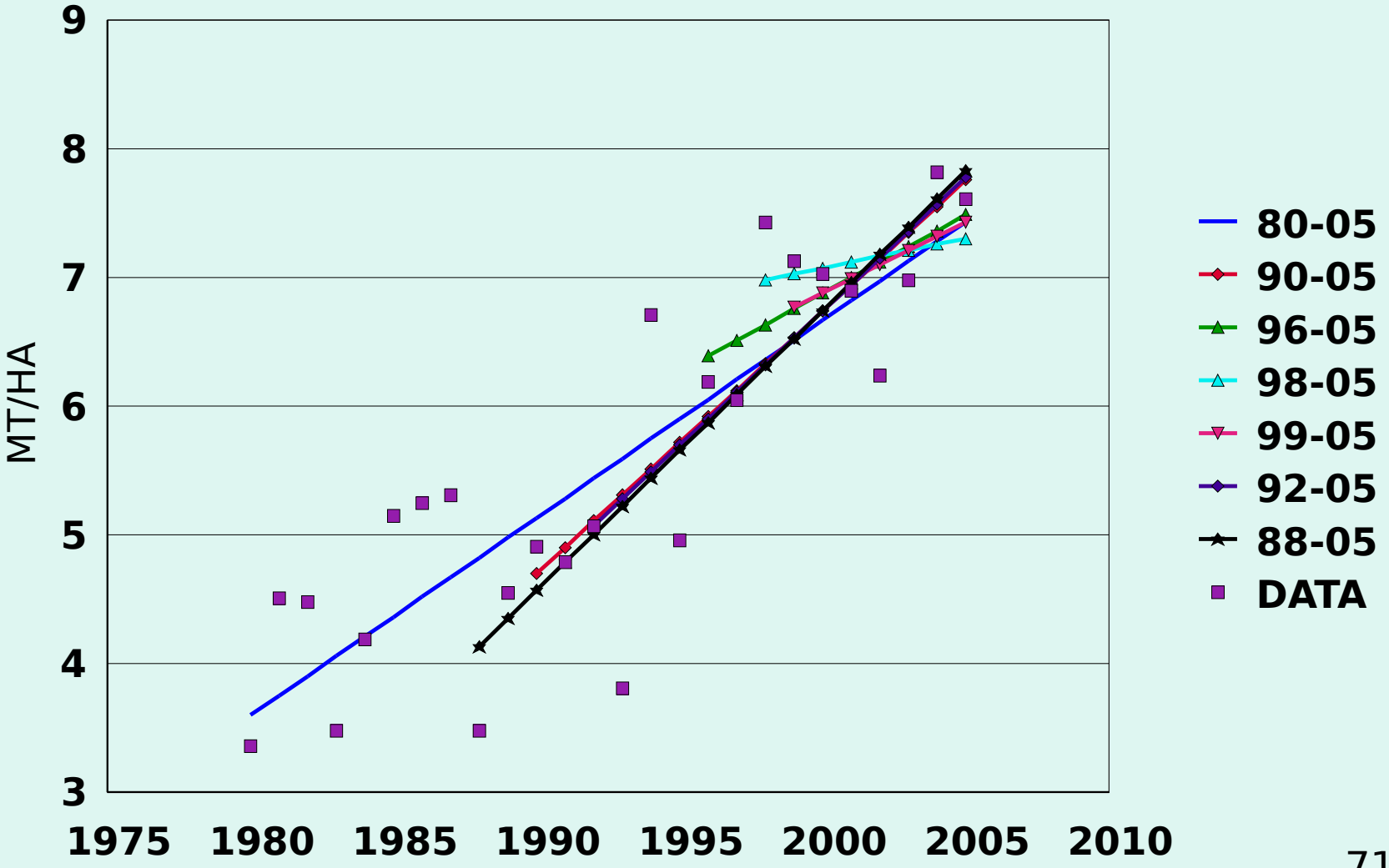
Northern Plains (ND & SD) Corn Yield Trends Over Selected Time Periods



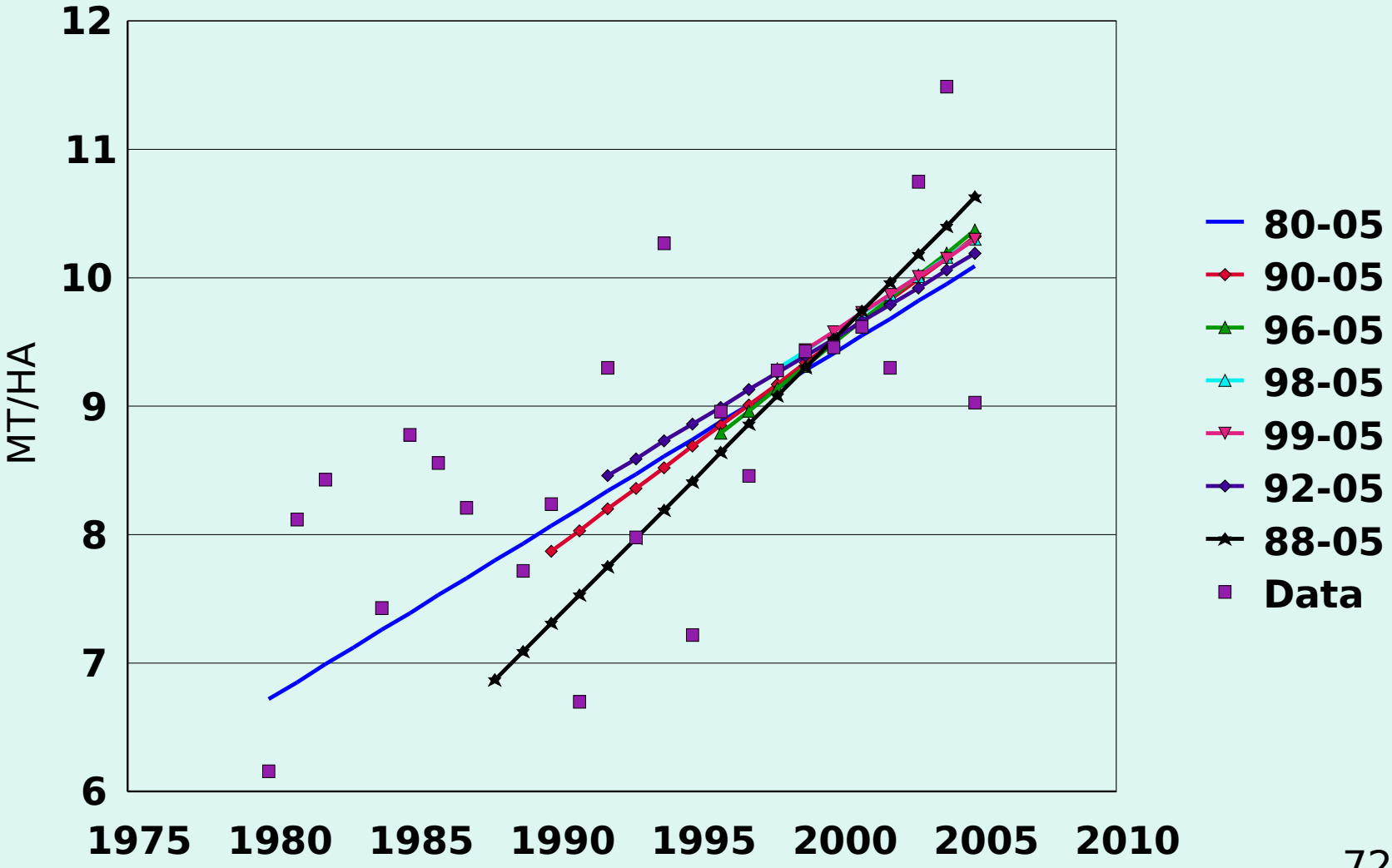
U.S. Corn Yield Trends



Northern Plains (ND +SD) Corn Yield Trends



Northern Illinois Corn Yield Trends



CRP as solution to ethanol growth

- 37 million acres in CRP.
  - There are 3 million acres in CRP that would be available for 2008
- The ability to release area from CRP for this purpose is not as easy as posed.
  - industry was looking for 4-8 million acres of corn for next growing season.
  - Johannes has made no decision about paring down CRP to allow more planting for biofuels, and said plans to kick out acreage are baseless.
  - Land in CRP would face steep penalties if ended before the contracts expire and there are substantial costs to getting land prepared and ready for cropping.
  - Johannes ..recently indicated USDA is reconsidering the CRP program with decision

- Mann Global Research 2006c reported that the trade is fully aware that up to 3 million CRP acres could be available in 2007.
  - CRP land is of questionable agricultural value, with the biggest chunk in Texas, Kansas and North Dakota.
  - Some of this could be switched into wheat, but corn would be unlikely.
  - Crop land coming out of production in the Corn Belt is limited, with Minnesota and Iowa at about 300,000-500,000 acres.

- Farmers with CRP could opt out of the contracts, they would incur penalties to do so (Pates, 2006).

- Bottom line: Congress should/will be forced to re-assess allowing some flexibility for CRP

Modal and Handling rates

- Handling
- Truck
- Barge
  - Rate functions
  - Delay costs
- Rail
- Comparisons
- Ocean rates

Modal and Handling rates: Caution

- In many cases, we are splitting <$1/mt differences among least cost movements!

Handling Fees

- Separate handling fees imposed for additional costs of selected movements
  - Barges
  - Great Lakes
- Handling costs also included for competitor exporting countries
  - From tariffs and/or from industry contacts
  - About 1-1.50/mt in US, and more for other countries

Barge Transfer Costs

Function	*c/b*	*$/t*	*Conversion*	*$/mt*
Transfer	3	1.05	35.00	1.10
Direct	4	1.43	35.75	1.47
Rough	5	1.45	29.00	1.84

Handling Fees on the Great Lakes

Element/function	*Units*	*US via* Duluth	*US via* Toledo	*Canada via* T. Bay
	c/b	$/t	$/t	C$/*mt*
Port Elevation 1	2000 lb	2.75	2.25	8.17
Laker rates to St. Law	2000 lb	8.75	5	15
Locakage (incl other)	2000 lb	3	3	3
Transfer elevator	2000 lb	2.75	2.75	2.59
Total: Fob Ship St. Lawrence		17.25	13	28.76
		$/mt	*$/mt*	*$/mt*
Country elevation				
Port Elevation 1		3.03	2.48	5.20
Laker rates to St. Law		9.65	5.51	9.55
Locakage (incl other)		3.31	3.31	3.31
Transfer Elevator		3.03	3.03	1.65
Total: Fob Ship St. Lawrence		19.01	14.33	19.71

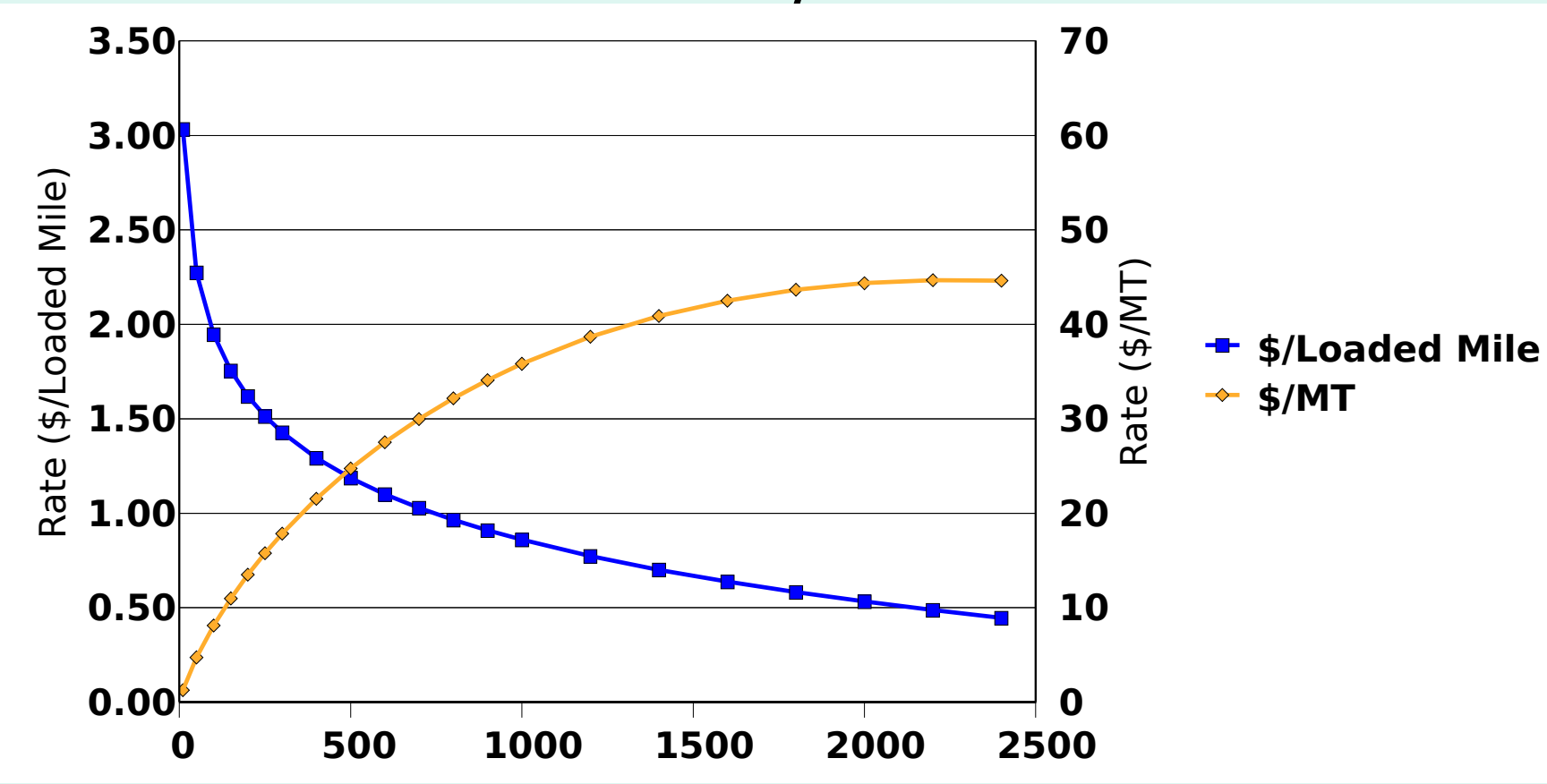
Handling Cost Adjustments

- From Dager et al April 2007 based on field surveys
- Added soybean handle of 6c/b/handle due to wear and tear on equipment and industry practices
- Add $2.50/mt to rail cost at the usg for added demurrage and testing costs (Chris).
  - Gulf handing differentials: there are added costs for rail vs barge: +_2-3$/mt.
  - Due to added inspection (car vs barge), demurrage, and handling differential [barge to elev=2.50/t; rail to elev 2.75/t; midstream to elev=1.75/t;

Truck rates

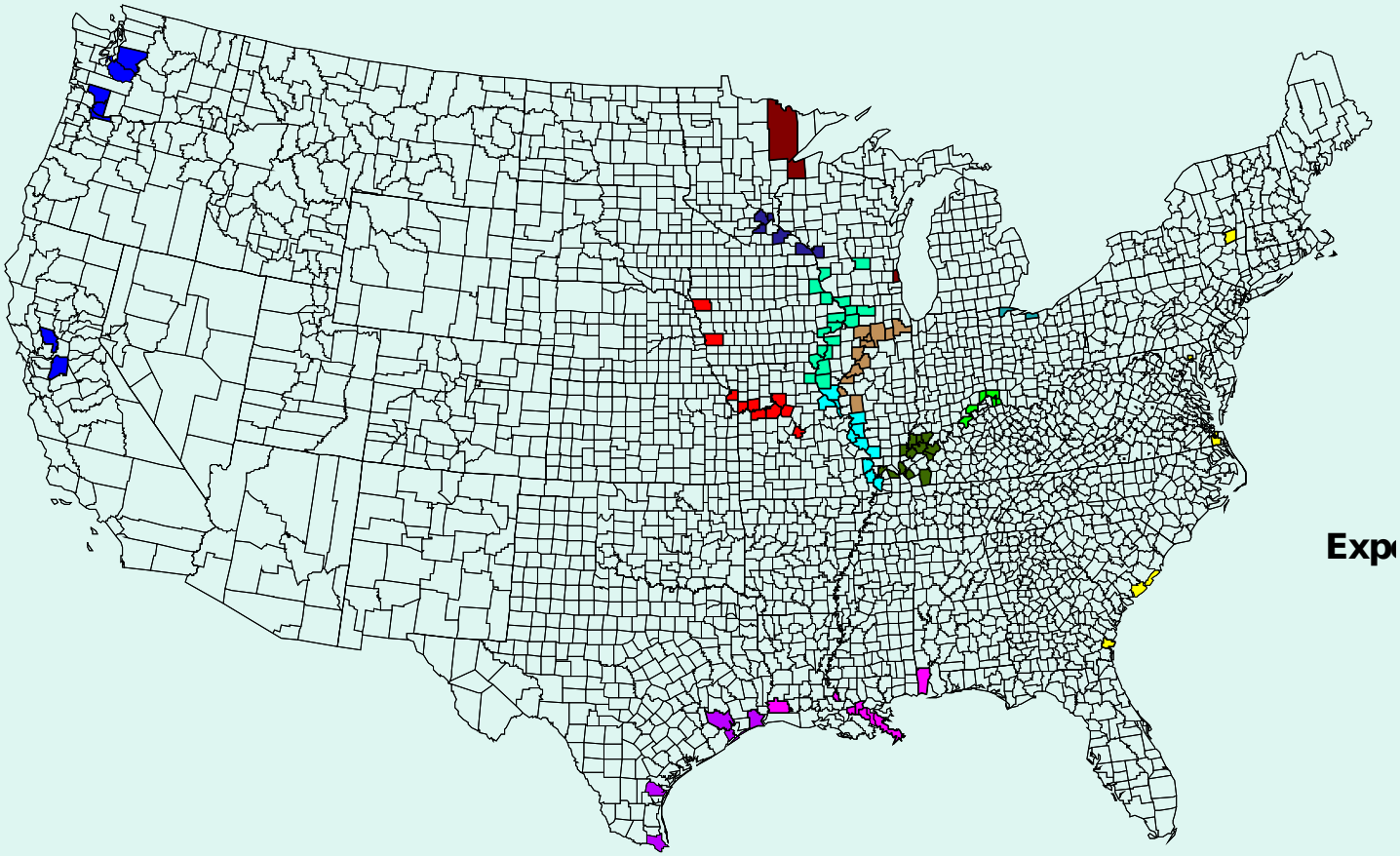
- Used to allow for truck to barge shipping locations
- Distance matrix estimated:
  - centroid of each prod region to export and barge loading regions, and domestic regions
- For shipments to domestic markets:
  - Rate function derived from trucking data from USDA AMS for ship
  - 4th Qtr 2003 to 3rd qtr 2004.
- Truck costs to River
  - from Dager (forthcoming April 2007)

Estimated Relationship Between Distance, Rate/Loaded Mile and Cost/mt



Barge Rates

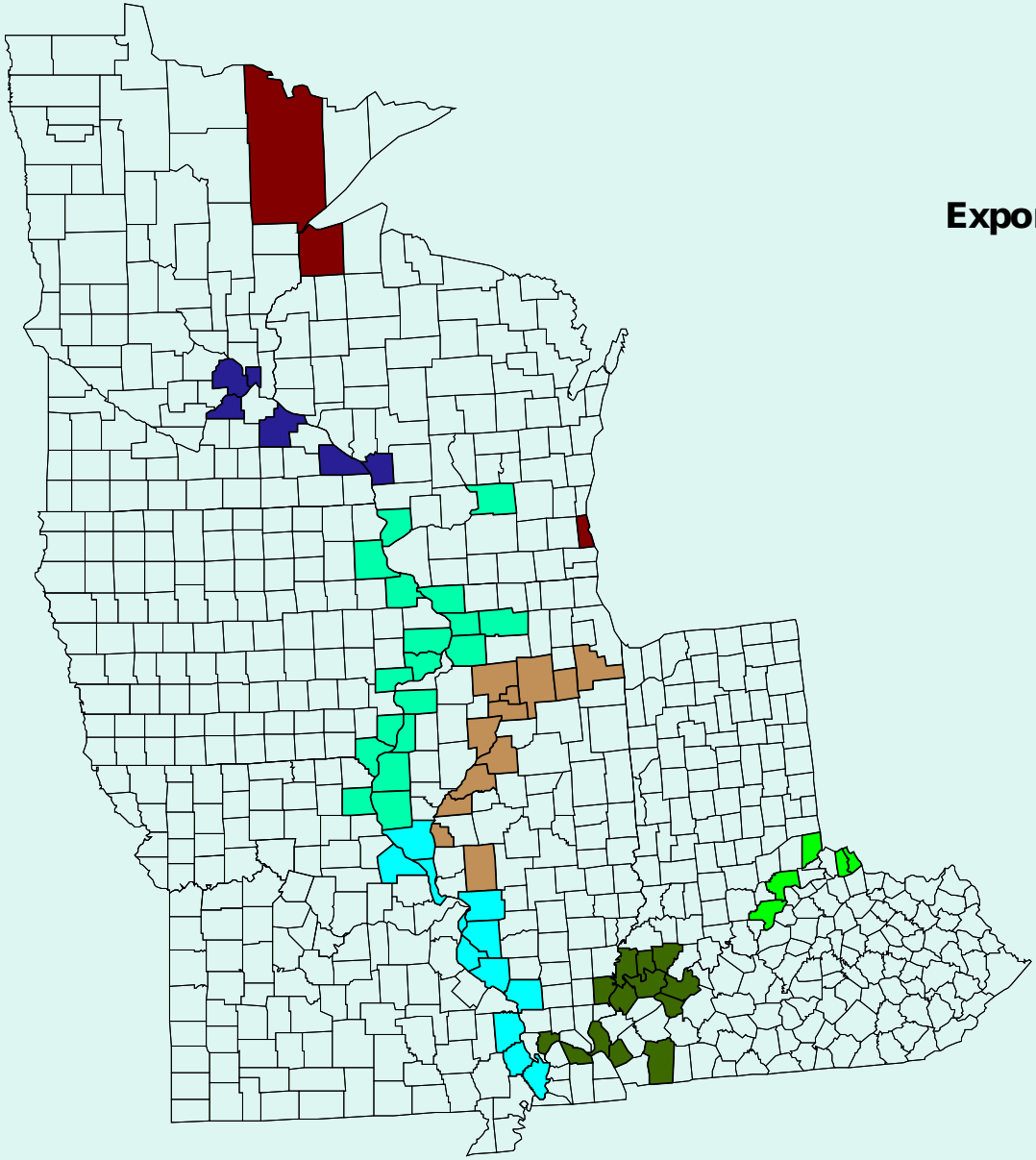
Export Reach Regions



Reach Definitions

- Reach 1 - Cairo - LaGrange (St. Louis);
- Reach 2 - LaGrange to McGregor (Davenport);
- Reach 3- McGregor to Mpls (Mpls);
- Reach 4-Illinois River (Peoria);
- Reach 5 Cairo to Louisville (Louisville);
- Reach 6 Cincinnati (Cincinnati)

Reach Definitions



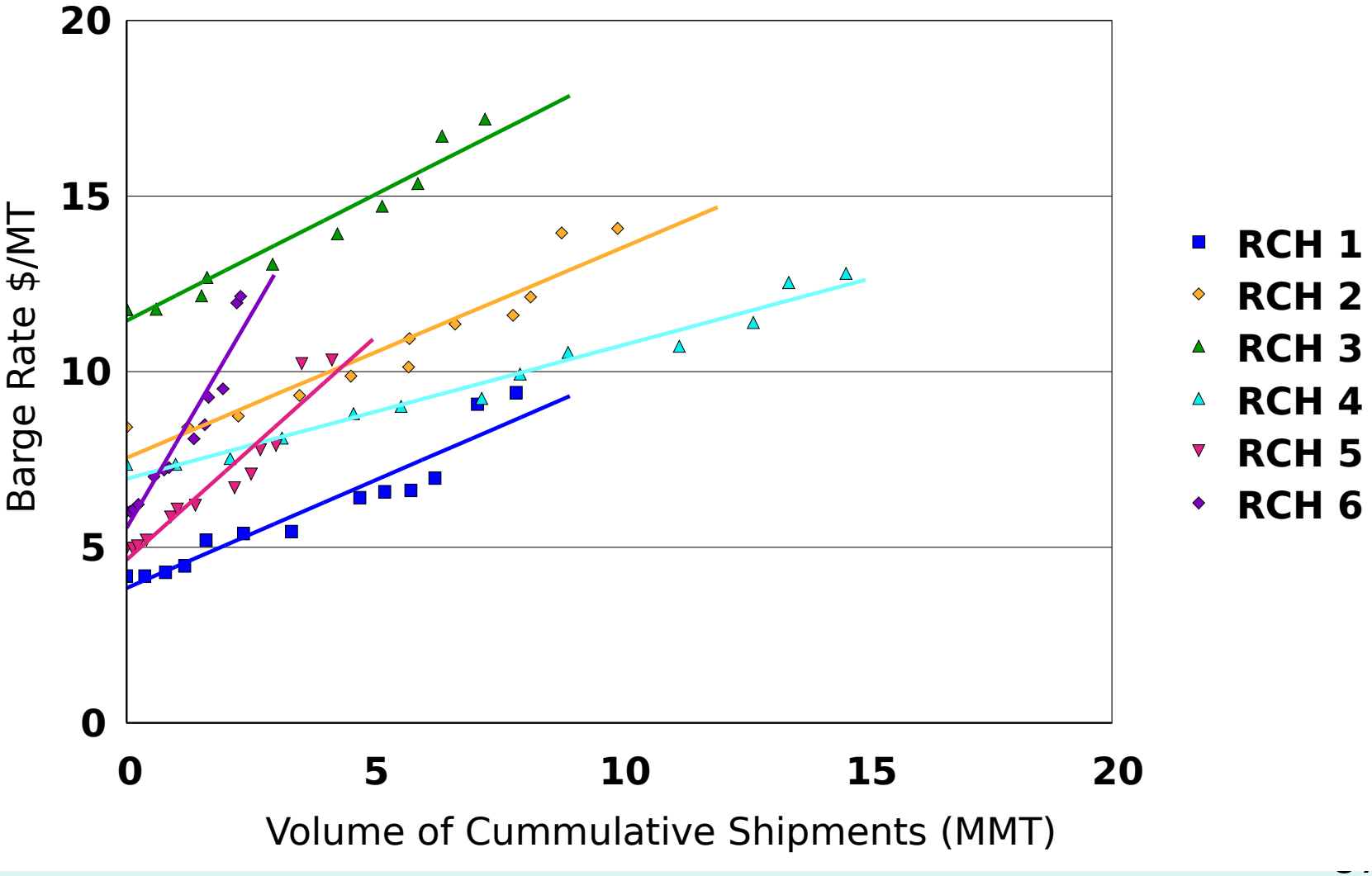
Export Regions

- **Dul/Sup**
- **EC**
- **Missouri**
- **NOLA**
- **PNW**
- **RCH1**
- **RCH2**
- **RCH3**
- **RCH4**
- **RCH5**
- **RCH6**
- **TXGulf**
- **Toledo**

Barge Rates

- Barge rate functions (instead of barge rate levels)
  - Critical (essential for solution)
  - Numerous nil movements on Reaches
  - Missed values by c/mt
- GAMS implications: Nonlinear programming

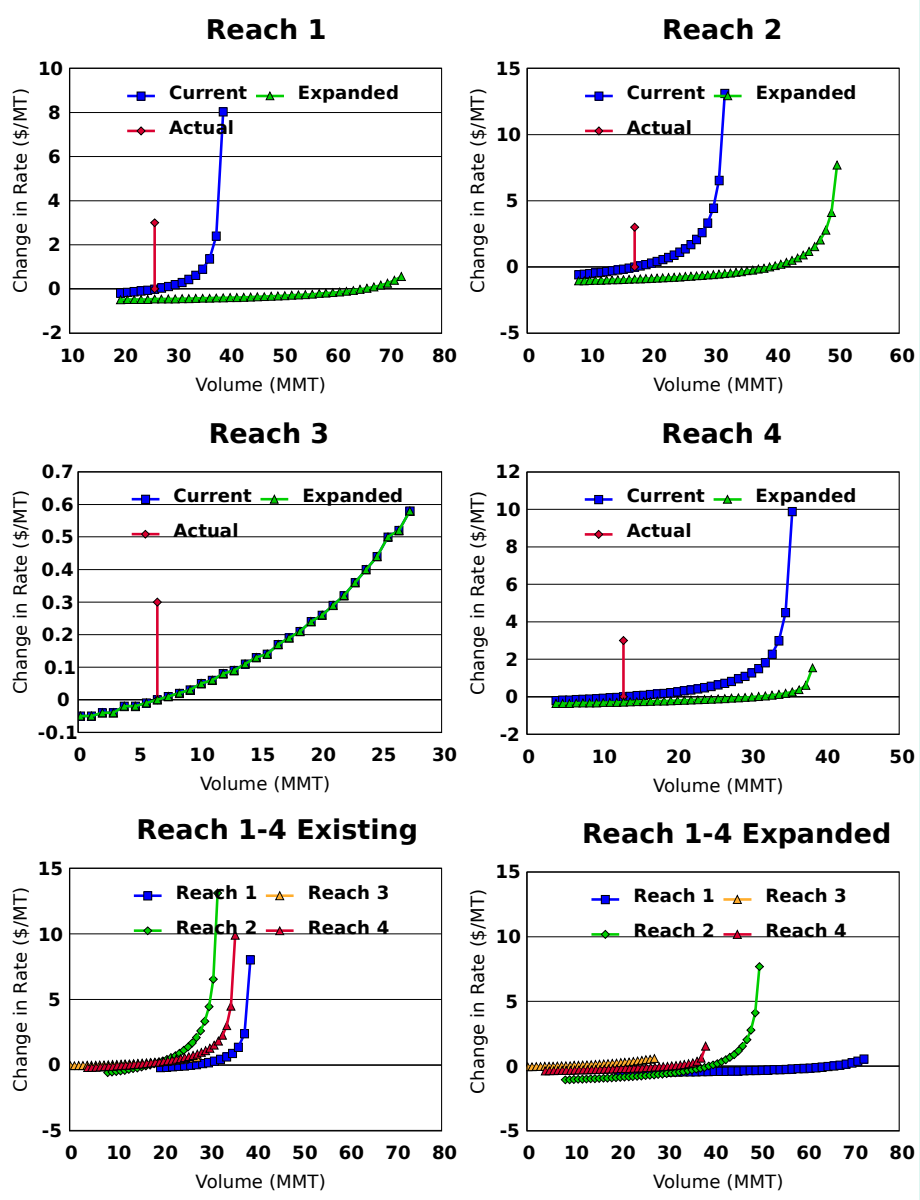
Barge Rate Functions



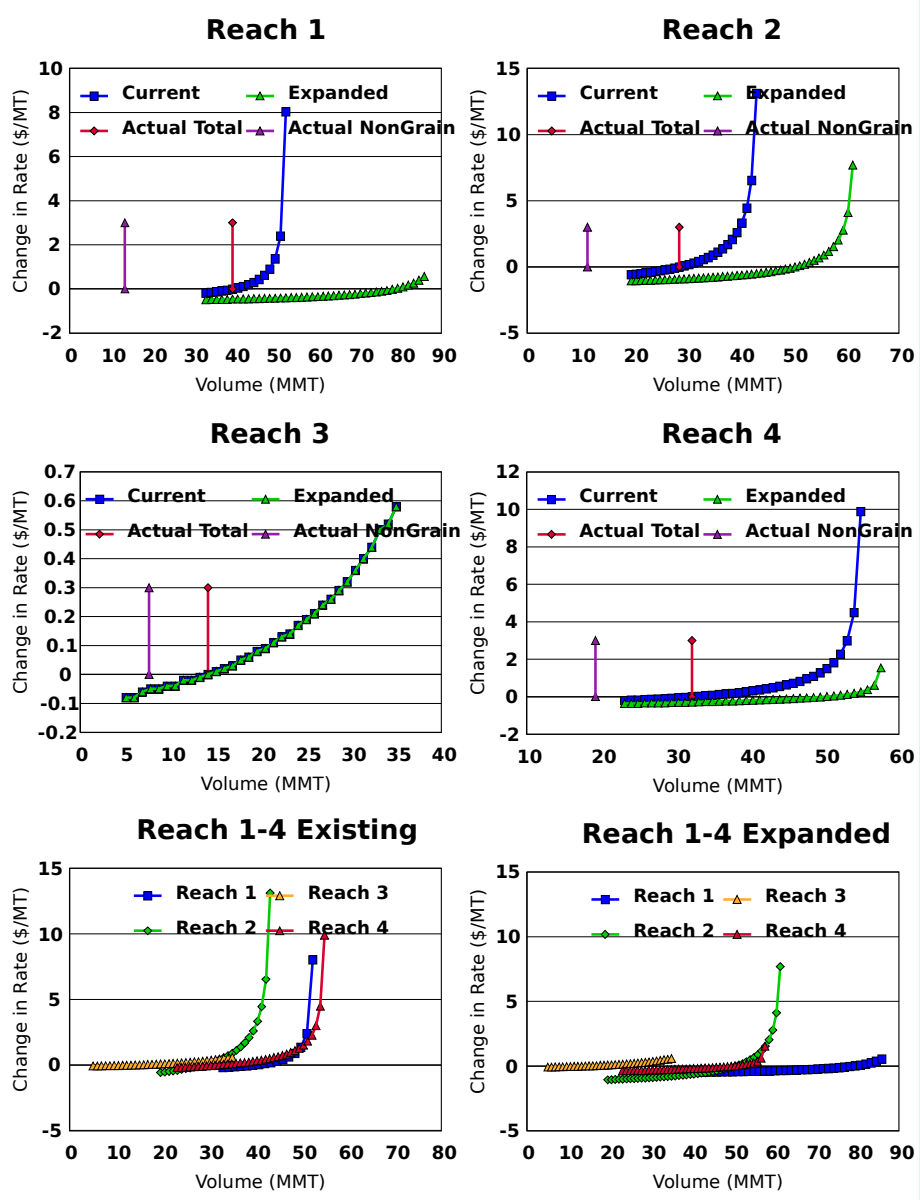
Delay Costs and Volumes Existing and Expanded Capacity

- Derived through simulation
- Barge capacity-volume relationship was estimated for each lock within the reach.
- Model was developed where
  - Average wait time = *f*(volume); and,
  - Cost = *f*(wait time)
- Results in hyperbolic function
  - GAMS had problems solving due to non-linear nature of delay costs
  - Respecified as a double-log function
- Factors impacting the cost include
  - value of grain, equipment and labor costs.
- Delay costs represent the sum of the delay curves at individual locks within the reach.
- Normalized
  - defined relative to “normal traffic” assumed for other commodities, both upbound and downstream traffic, and reflect the incremental impact on cost for an assumed change in grain traffic.
  - annualized using procedures in Oak Ridge National Laboratory (2004)

Barge Delay Functions (Grain Volumes Only)



Barge Delay Functions (Total Volumes)



Rail rates

- Source
  - STB confidential/private data set
- Cautions: STB not clear/consistent on treatment of
  - FSC's
  - COT/Shuttle payments
- Weighted average 2000-2004
  - Updated to 2004
  - careful revisions/modifications.
- Missing rates: If rate is missing
  - Movement not allowed
- Subtracted $2/mt for shuttle train rebates to PNW

Export Rail Rate Comparison

Corn: Rail and Barge Rates

Table 5.3.1. Corn: Comparison of Rail-Barge vs. Direct Rail to Gulf, Average of 2000-2004 ($/MT)

	Rail	Barge	Total	Least Cost
Northern Illinois				
RCH1	6.55	5.81	12.36	
RCH4	3.95	9.97	13.92	
NOLA	10.69		10.69	**
Minnesota				
RCH3	8.36	14.03	22.39	
RCH2	10.16	10.71	20.87	**
RCH1		6.51		
NOLA	24.23		24.23	
TX Gulf	24.12		24.12	
Minnesota River				
RCH3	5.53	14.03	19.56	**
RCH2	9.23	10.71	19.94	
RCH1	13.99	6.51	20.50	
NOLA	25.21		25.21	
TX Gulf				

Wheat: Rail and Barge Rates

Table 5.3.2. Wheat: Comparison of Rail-Barge vs. Direct Rail to Gulf, Average of 2000-2004 ($/MT)

	Rail	Barge	Total	Least Cost
Northern Illinois				
RCH1	12.16	6.51	18.67	
RCH4		9.97		
NOLA	11.75		11.75	**
Minnesota				
RCH3	16.48	14.03	30.51	
RCH2	23.61	10.71	34.32	
RCH1	23.21	6.51	29.72	
NOLA	36.85		36.85	
TX Gulf	28.16		28.16	**
Minnesota River				
RCH3	7.52	14.03	21.55	**
RCH2		10.71		
RCH1	18.46	6.51	24.97	
NOLA				
TX Gulf	50.60		50.60	

Soybeans: Rail and Barge Rates

Table 5.3.3. Soybeans: Comparison of Rail-Barge vs. Direct Rail to Gulf, Average of 2000-2004 ($/MT)

	Rail	Barge	Total	Least Cost
Northern Illinois				
RCH1	10.01	6.86	16.87	
RCH4	2.54	9.60	12.14	**
NOLA	13.19		13.19	
Minnesota				
RCH3	13.22	14.03	27.25	
RCH2	15.22	10.71	25.93	
RCH1	14.77	6.51	21.28	**
NOLA	24.56		24.56	
TX Gulf	27.79		27.79	
Minnesota River				
RCH3	7.89	14.03	21.92	
RCH2	7.87	10.71	18.58	**
RCH1		6.51		
NOLA	23.62		23.62	
TX Gulf	35.07		35.07	

Summary on Rail/Barge Rate Competitiveness

- Corn
  - Shipments from Northern Illinois favor direct rail to the U.S. Gulf, followed by shipments via Reach 1.
  - From Minnesota the least cost is by barge through Reach 2 and from Minnesota River regions the least cost is by barge from Reach 3;
- Wheat
  - The least cost movement from Northern Illinois is direct rail (by nearly $7/mt);
  - direct rail to Texas Gulf from Minnesota (by over $2/mt);
  - from the Minnesota River to Reach 3 and then barge to U.S. Gulf;
- Soybean
  - Shipments via Reach 4 from Northern Illinois is least cost.
  - Barge shipments via Reach 1 from Minnesota and from Reach 2 from Minnesota River are least cost.
  - The advantage of Reach 1 versus Reach 3 is about $6/mt; and of Reach 2 versus Reach 3 is about $3.50/mt.

Rail Rates on Barge Competitive Routes: Iowa River and Rail Shipment:

- Inspection of the STB data on volume it is apparent that
  - shipment from Iowa River to the Western corn belt are not nil.
    - Rail shipments for this flow have increased from near nil in 2000 to 443,296 mt in 2004.
  - Rail volume from Iowa West to the Western Corn Belt from 2000 to 2004 has been decreasing over time (1.6 mmt to 0.7 mmt).

- Major point
  - Cannot assume that river-adjacent locations ship all to River
  - Growth in volume to non-River destinations

Shipping and Handling Restrictions

- PNW handling restriction in sensitivity
  - set at 30 mmt (comparable to current handle)
- Rail capacity included
  - Base case restricted to = 141 MMT
  - Alternatives values in sensitivities
- Derived from USDA/AAR data in *Grain Transportation*
- Used as sensitivity
  - Debatable if it is a longer term constraint

Ocean Rates: Japan to U.S.

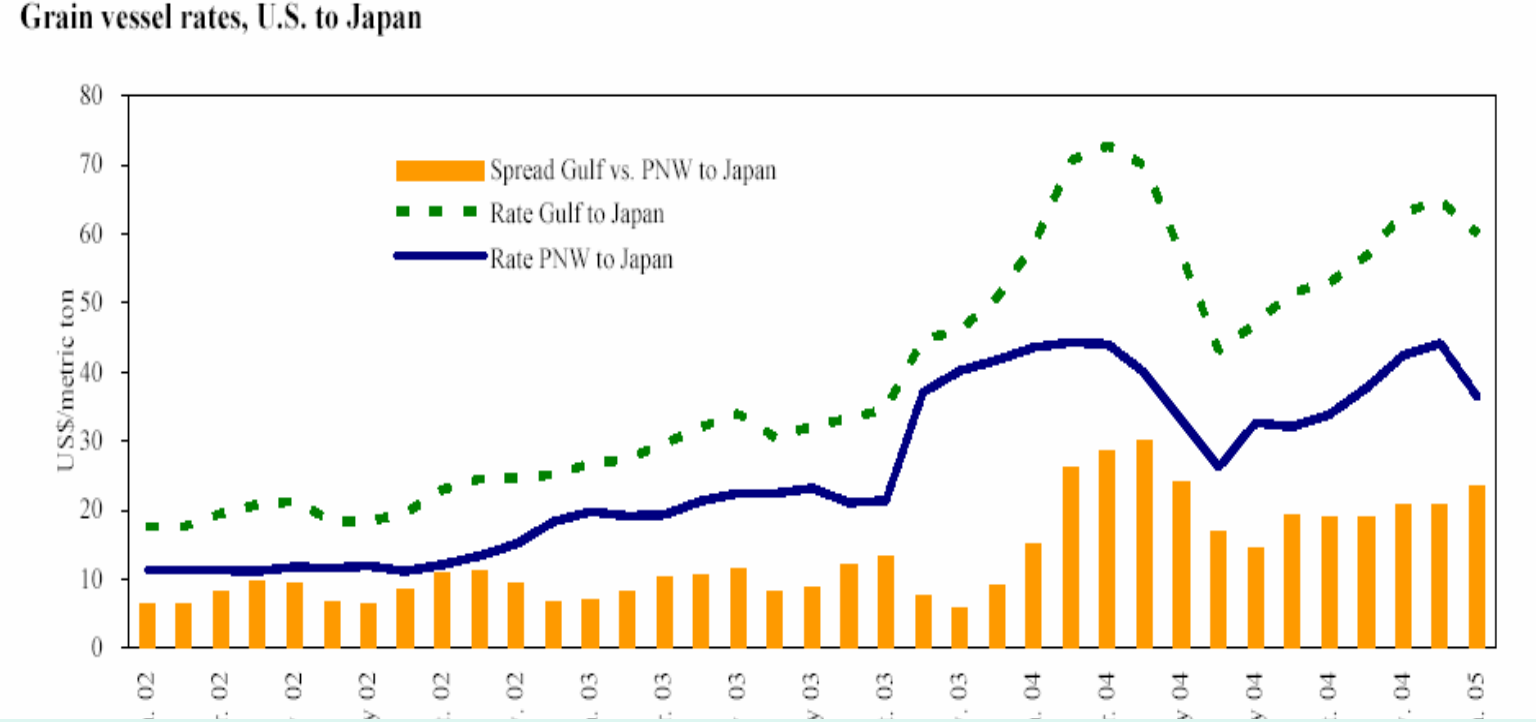


Figure 5.5 Grain Vessel Rates, U.S. To Japan.

Ocean Shipping Rates

- Rates from IGC
- Estimated rate functions
  - To deal with unreported origins/destinations
- Applied to generate ocean shipping matrix

Summary: Major factors impacting results

- *Growth markets*:
  - For corn and soybeans, there is fairly rapid growth in export demand (driven by population and income);
  - wheat is lesser
  - most important and fastest growth markets, in terms of consumption
    - corn and soybeans are China, North Africa, South Africa and the FSU and Middle East.
- *Corn Used in Ethanol:* Corn used in ethanol production is expected to increase from
  - four billion gallons to nearly 10 billion gallons in 2015, and then converge to about 11 billion gallons in 2020 forward.
  - More recent studies suggested this could be greater and all point toward severely reduced exports
  - Most likely is 12 bill near term; longer term 15-18 and thereafter depends on policy, competing ethanol technologies and GM productivity growth

Summary: Major factors impacting results

- *Grain production costs and international competition:* There are substantial differences in production costs. In particular:
  - the US is the lowest cost producer of corn and soybeans;
  - most US regions' production costs for soybeans are less than those in Brazil, and those in Brazil South are less than those in Brazil North; and other countries have lower costs for producing wheat than those in the United States.
  - Doesn't matter: Model uses all that is produced!
- *Intermodal competitiveness:*
  - It is critical that rail rates are less than barge shipping costs for some larger origin areas and movements.
  - In some cases the direct rail cost to the US Gulf is less than barge shipping costs.
  - Econometric analysis suggests that over time there have been productivity increases in rail, which has resulted in reduced real rail rates.

Delay Costs

- Several Reaches are near the point at which positive delay costs are accrued.
  - At higher volumes, delay costs escalate and ultimately become nearly vertical.
- Proposed improvements would have the impact of
  - shifting the delay function rightwards
    - meaning that near-nil delay costs exist for a broader range of shipments.
- More aggressive assumptions on non-grain traffic has the impact of
  - Increasing delay costs on grain;
  - Reducing delay costs if expansion occurs

Econometrics of modal rates

- Concerns
  - Changes (prospective) in relative rate relationships may emerge
- The assumption is
  - rate relationships are the same in the future as during the base period.
  - relationships capture the salient variables and spatial relationships to others
  - do not allow for the prospect of alternative or changing marketing structures and pricing behavior.
- Extensive experimentation on econometrics of rates
  - Rates not responsive to fuel prices (through 2004)
  - Simultaneous relationships among modal rates (See below)
  - Data is unbalanced, non-synchronous across modes and some type of simultaneous estimators should be pursued.
    - These are not without challenges both from a data view, as well as an econometric perspective.

Rail Capacity

- Rail capacity:
  - car loadings for grains (as reported by USDA AMS) increased from 2002 to 2005.
    - vary across railroads;
  - It is not clear how the longer-term adjustment will evolve.
  - Different ways to measure capacity
    - What is observed (as referenced above) is loadings, which in concept would be the equilibrium of demand and capacity allocated to grain.
    - Interpretation is further compounded by rail capacity due to other factors (track space, crew, locomotive all of which compete with other commodities), and that though we observe current shipments, more important for this type of analysis is future capacity.
  - Thus, it is important to assess the longer-run adjustment curve on the part or railroads.

Model Specifications

- Given the size and complexity of this model, there obviously a number of alternative approaches.
- In rank order, those that would likely have the greatest impact on the results would be
  - elasticity of substitution amongst modes, estimate these and include in the model (data exists to do this, and would allow less extreme shifting amongst modes in response to critical variables);
  - explicit supply and demand functions for underlying commodities (but, this is not inconsequential due to the disaggregated specification of the model); would not impact intermodal competitive issues.

Other Extensions

- Others features could be included into the model
  - Biodiesel: implicitly already in model
  - DDG Shipping
  - Ethanol shipping
- Unlikely to impact results
  - Highly speculative regarding numerous aspects including
    - Shipping rates
    - Equipment and practices